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The
TECHNIQUE
of
PICTORIAL PHOTOGRAPHY

SOLITAIRE
BY PAUL L. ANDERSON
From a Platinum Print

The TECHNIQUE of PICTORIAL PHOTOGRAPHY

by

Paul L. Anderson

With 28 Illustrations and 31 Diagrams

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PICTORIAL PHOTOGRAPHY
Its Principles and Practice

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THIS BOOK IS AFFECTIONATELY INSCRIBED TO MY DEAR WIFE, WHO HAS AIDED IN ITS PREPARATION IN EVERY WAY POSSIBLE, BUT ESPECIALLY BY ANSWERING THE TELEPHONE AND SAYING: "NO, HE'S OUT JUST NOW, BUT IF YOU'LL LEAVE YOUR NUMBER I'LL HAVE HIM CALL YOU."

"God hath made man upright; but they have sought out many inventions."

ECCLESIASTES VII, 29

"Men have invented a lot of things, but no one has ever yet invented a satisfactory substitute for brains."

A. K. ASTER

FOREWORD

The present volume was originally planned as a revised edition of the author's earlier work, Pictorial Photography, Its Principles and Practice. But as soon as the work of revision was begun, it became evident that since the appearance of the former book, in 1917, there have been such a tremendous growth of interest in photography, such a vast increase in the knowledge of technical processes, such an improvement in materials and apparatus, and so many new designs of apparatus, as to demand almost a complete re-writing of the text. Some of the information included in the older book, especially the theoretical discussions, has been retained, but in general the re-writing has been so extensive as to justify publication of this as a new book.

No attempt has been made to enumerate or to discuss all of the developments which have taken place during the past twenty-two years; to do so would require a score of books the size of the present one. But it has been the author's effort to consider such of these developments as may be considered valuable to the pictorial photographer, to the worker who believes that photography can be a medium of fine art expression, and who works in that belief. Evidently, therefore, this cannot be considered a complete handbook of photography; the author hopes,

though, that it may be of service as a textbook of—as the title indicates—the truly pictorial phase of this art, and the present volume is offered in that spirit.

Since the purpose of this book is identical with that of the earlier one, it seems well to include here an extract from the foreword of 1917, as follows:

> In preparing the discussion of the technique of pictorial photography which is given in the following pages the author's purpose has been to produce a book adapted to the needs of those workers who, without wishing to undertake a study of the abstruse scientific phases of the art, nevertheless have passed beyond the elementary stages and feel a desire for pictorial expression. Every effort has been made to adapt the book to the needs of such photographers, and for that reason the author has endeavored to make clear, not only the actual technical methods, but also the fundamental principles underlying those methods, since a thorough grasp of the principles is of importance in enabling the worker to locate and to correct his mistakes and also to study and to grow in power of expression, which is almost impossible when his knowledge is simply a matter of remembering certain arbitrary facts.
>
> Inasmuch as pictorial photography only is being dealt with, some subjects which would otherwise find a place in a textbook have not been discussed, the most conspicuous omission of this sort being in the case of gas-light papers, which, though valuable to the commercial worker, have not great usefulness to the pictorialist, because of their lack of absolute permanence and of the highest esthetic quality. However, the author has in his own work given especial attention to the various printing processes which are of value to the pictorial worker, and feels that the discussion of these mediums is satisfactorily complete. . . .
>
> It has seemed well to include examples of the work of noted photographers, for the sight of such work is a more powerful stimulus and incentive than any amount of verbal discussion.

The author herewith extends his grateful appreciation to the following individuals and firms who have, in one way or another, assisted in the preparation of this work. For illustrations for reproduction, the Eastman Kodak Company; the Agfa Ansco Company; Carl Zeiss, Inc.; the Photo Marketing Corporation; Burleigh Brooks, Inc.; Simmon Brothers; Bell & Howell Company; and the various photog-

raphers who have so kindly contributed the pictorial illustrations. For permission to reprint various formulæ, Messrs. Crabtree and Matthews. For valuable technical suggestions, Mr. Kirtland Flynn. For the apparatus used in developing Fresson prints, Mr. William G. Houskeeper. And for copyreading, for many helpful suggestions, and for much extremely valuable experimental work, offered in the most generous spirit, Dr. A. K. Aster.

PAUL L. ANDERSON

EAST ORANGE, N. J., 1939

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PART I

APPARATUS

CHAPTER I

The Camera

FUNCTION.—Fundamentally, the camera is nothing more than a light-tight box, having an arrangement for holding a light-sensitive substance (plate or film) and a device (lens or pinhole) for projecting on this sensitive substance an image of objects external to the camera. Some of the simpler cameras approximate closely to this elementary form, but in practice other adjustments are usually added, either to make possible work which could not be done with the fundamental type, or to facilitate work of one kind or another. Some adjustments and characteristics are incompatible with others, so the design of the camera must always be in the nature of a compromise, and the instrument should be chosen with regard to the purpose for which it is desired.

ADJUSTMENTS.—The ideal camera for pictorial work would possess the following adjustments and characteristics:

A folding bellows, operated by rack and pinion, with an arrangement for locking at any desired extension, and a maximum draw of not less than twice the focal length of the lens to be employed. (For focal length of lens see Chapter II.) As will be seen later,

the farther the object is from the camera the less the bellows extension necessary, and the closer it is the farther the lens must be from the film in order to focus on it, a maximum extension of twice the focal length of the lens permitting of making the image the same size as the original, this being about the limit that is usually desired, except for special work, such as reproduction.

Rising and Falling Front.—That is, a device whereby the lens may be raised without the necessity of tilting the camera. This is useful in raising or lowering the image on the plate, as is indicated in Figure 1.

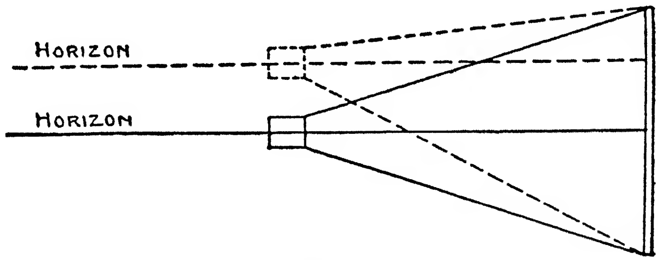

FIG. 1

Traversing (or Sliding) Front.—This is an arrangement whereby the lens may be moved back and forth across the bed of the camera. The purpose is apparent from Figure 1.

Swing-back.—This is a device by means of which the back of the camera, together with the plate or film, may be swung through a small arc about either a horizontal or a vertical axis. The swing about a horizontal axis is the more important, the other

swing being desirable but less valuable. A swing front, permitting of tilting the lens, serves the same purpose, and is sometimes furnished. Whether the swing is of the back or of the front, it should preferably be actuated by rack and pinion, and be capable of locking at any desired point. The function of the swing-back is twofold. In the first place, as stated above, the lens must be farther from the film to focus on nearby objects than when the objects are more distant. Hence it follows that, say, in landscape work, unless using the very short focus lenses supplied on miniature cameras, it will be impossible to focus at full aperture of the lens on both foreground and distance simultaneously if the film is at right angles to the axis of the lens. By swinging the top of the film (since the image is inverted) farther from the lens the foreground and distance may be brought into focus at the same time without the necessity for using a small diaphragm in the lens (see Figure 2). In the second place, if we are photographing a tall object

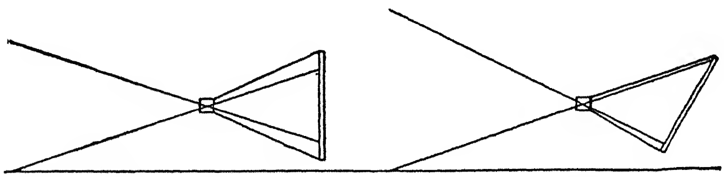

FIG. 2

and find it necessary to tilt the camera in order to include the desired amount, parallel vertical lines will converge in the negative. If, however, the back

be swung so as to remain parallel to the plane of the object (that is, vertical) this effect will not appear. This is not of much consequence in landscape work, where we rarely find parallel lines, but is of primary importance in architectural photography.

Rotating (Usually Called Revolving) Back.—This permits of arranging the film with the long axis either vertical or horizontal as may be desired, without the necessity of turning the camera on its side. It is sometimes furnished as a reversible back, which must be detached from the camera in order to turn it, and this form is quite as desirable as the other.

In addition, the camera should be so designed and constructed as to be perfectly rigid when fully extended, should be strong enough to withstand ordinary use, and should be light and capable of being folded into a small space for transportation. For pictorial work it is also important that the front-board be large, since lenses of large aperture and comparatively great focal length will ordinarily be employed. Finally, it is strongly recommended that the student begin with a camera having a ground glass, since practice in arranging the picture is of inestimable value in the study of composition, and a view-finder is too small to make such practice possible. The miniature cameras, as well as the folding film type, valuable as they are to more experienced workers, cannot be considered desirable for beginners. In order to facilitate practice in composition, and also because a large print is undeniably more impressive than a

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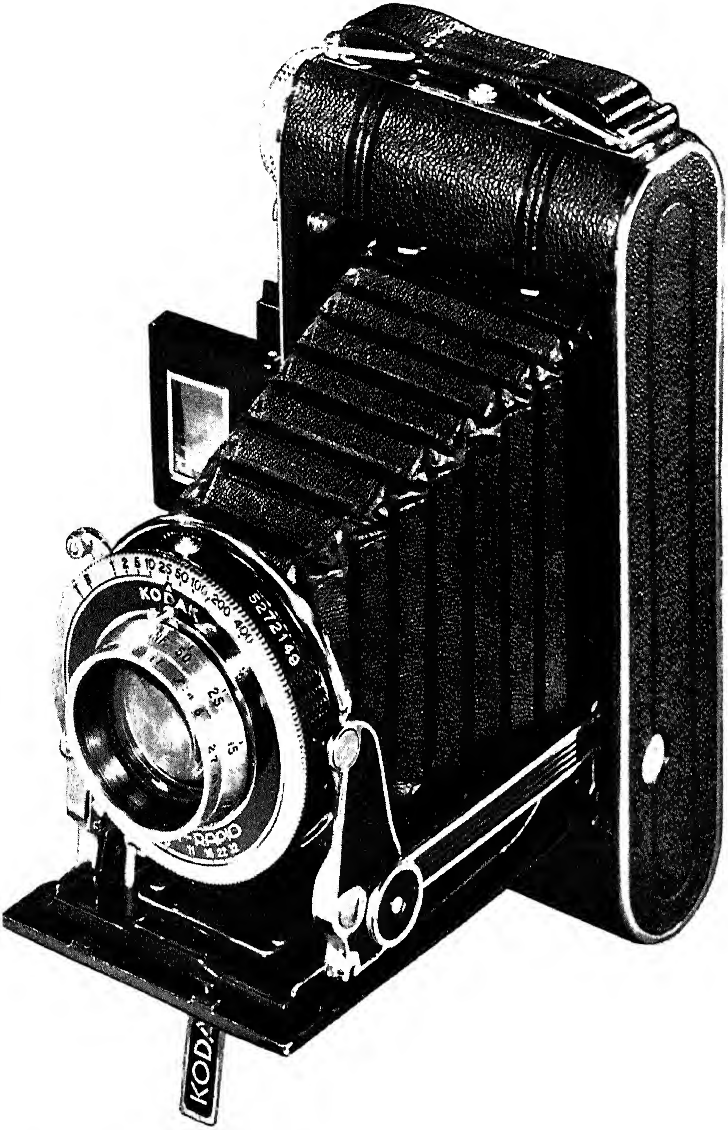
FIG. 3.—BOX CAMERA



By courtesy of The Eastman Kodak Company

FIG. 4.—FOLDING FILM CAMERA

small one, it is advised that the camera be as large as the student's strength will permit him to carry, and it will in general be found that 8×10 is about the limit in this regard for a man, and $6\frac{1}{2} \times 8\frac{1}{2}$ for a woman.

TYPES.—*Box Type.*—This is illustrated in Figure 3, and consists simply of a box having a lens (usually a single achromatic) in front, with a simple type of shutter, and a device for winding a roll of film so that successive portions are exposed to the image projected by the lens. Sometimes a film pack is used instead of a roll film, but the instrument is of the simplest, and need not be seriously considered here. True, good work has been done with such cameras, but only under the most favorable circumstances.

Folding Film Type.—This next higher development of the camera (Figure 4) adds the extensible bellows, sometimes the rising and falling front, and ordinarily has either a single achromatic lens or an anastigmat. The shutter is more complete in its adjustments than that of the box type, and may, in fact, be the highest type of between-lens shutter. The folding film camera, however, lacks the large front-board, the long bellows extension, the swing-back, and, as a rule, the focussing screen, so it cannot be considered a desirable instrument for the pictorial worker, being, in fact, designed for record work when compactness and portability are of importance. It is, however, possible to secure ground glass at-

tachments for certain cameras of this type, thus extending their usefulness.

Reflex Type.—This camera is one of the best for snapshot and high-speed work, and the writer's experience, as well as that of many well-known workers, indicates that it may be very useful to the photographer whose aim is purely pictorial, some artists even going so far as to discard all other types in favor of this one. As shown in Figure 5, a mirror is hinged at an angle of 45° to the axis of the lens, the image being projected on the mirror and reflected by it on a horizontal ground glass, where it may be examined by looking down into the hood. Pressing a lever at the side of the camera releases the mirror, which flies up to a horizontal position, allowing the image to be projected on the plate or film, and at the same time operating the shutter, which is of the focal-plane type. The advantages of this arrangement are that it is possible to focus on the object up to the instant of exposure, that very brief exposures (up to 1/1000 second) are possible, that the light-efficiency of the focal-plane shutter is higher than that of any other type, and that instruments of this sort are available with all desirable adjustments. The only disadvantages lie in the facts that such cameras are rather bulky and heavy, the weight becoming prohibitive in sizes larger than 5×7, and that they are expensive.

The Folding Hand Type.—This type, illustrated in Figure 6, varies greatly in design, being, in gen-

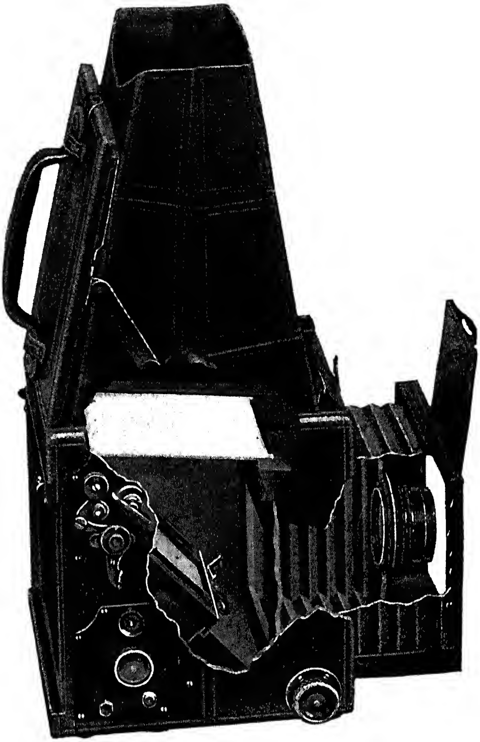


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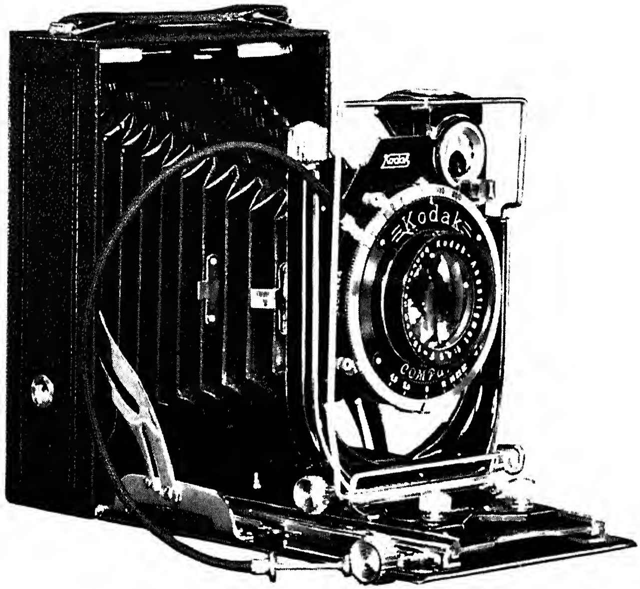
FIG. 5.—SECTIONAL ILLUSTRATION SHOWING PRINCIPLE OF REFLECTING CAMERA



By courtesy of The Eastman Kodak Company

FIG. 6.—FOLDING HAND CAMERA

eral, compact and light, and being obtainable with all desirable adjustments. So far as the writer knows, no camera of this style now made in America has a large front-board or the swing about a vertical axis, though one such was made in this country some years ago, and some English instruments possess these characteristics. With these limitations, this type is highly commendable, though somewhat expensive.

The View Type.—This camera (Figure 7) is the one which the writer recommends most strongly to both students and advanced workers, since it can be had with all desirable adjustments and is relatively cheap, the only drawbacks being the bulk and weight.

The Studio Type.—As the name implies, this camera (see Figure 8) is designed especially for use in the portrait studio, and, though possessing all adjustments, is too bulky and heavy to be carried about, this fact rendering it unavailable for landscape and genre work, as well as for home portraiture.

THE MINIATURE CAMERA.—There has been more or less discussion as to what constitutes a miniature camera, some writers claiming that a $2\frac{1}{4} \times 3\frac{1}{4}$ negative represents the largest of the miniatures, whereas others say that it is the smallest of the large cameras. It is, however, generally conceded that anything smaller than this is a miniature, so we will consider this type on that basis.

There are a great many makes of miniature camera, but they resolve themselves, broadly speaking, into four fundamental designs, making negatives ranging in size from approximately 1×1½ to 2¼×3¼ inches.

(1) *The Contax and Leica Type.*—These instruments take 35-mm. motion picture film, using two frames to each negative, so that the negatives are 24×36 mm., that is, nearly 1×1½ inches. Films are supplied in either 18-exposure or 36-exposure rolls, and it is also possible to load the magazines from film purchased in bulk. Both the above-named cameras are equipped with focal-plane shutters giving automatic exposures from 1 second to 1/1250 second, and a great variety of attachments may be obtained, including lenses of every useful focal length, and of apertures as fast as F/1.5. They are also equipped with direct-coupled view finders, so arranged that when the camera is out of focus two differently colored images of the principal object are seen; by moving a lever or a knurled wheel on the front of the camera these images are brought into coincidence, and when this occurs the camera is automatically focussed. These are very fine instruments of precision, but there are several cheaper—and of course less satisfactory—cameras made in imitation of them.

(2) *The Miniature Reflex Type.*—There are a number of cameras of this type, probably the best

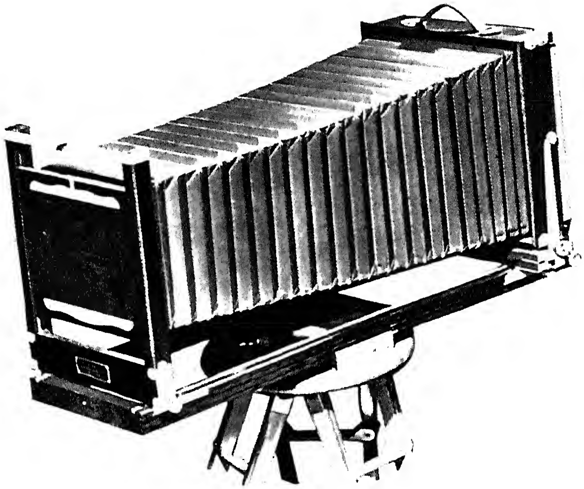


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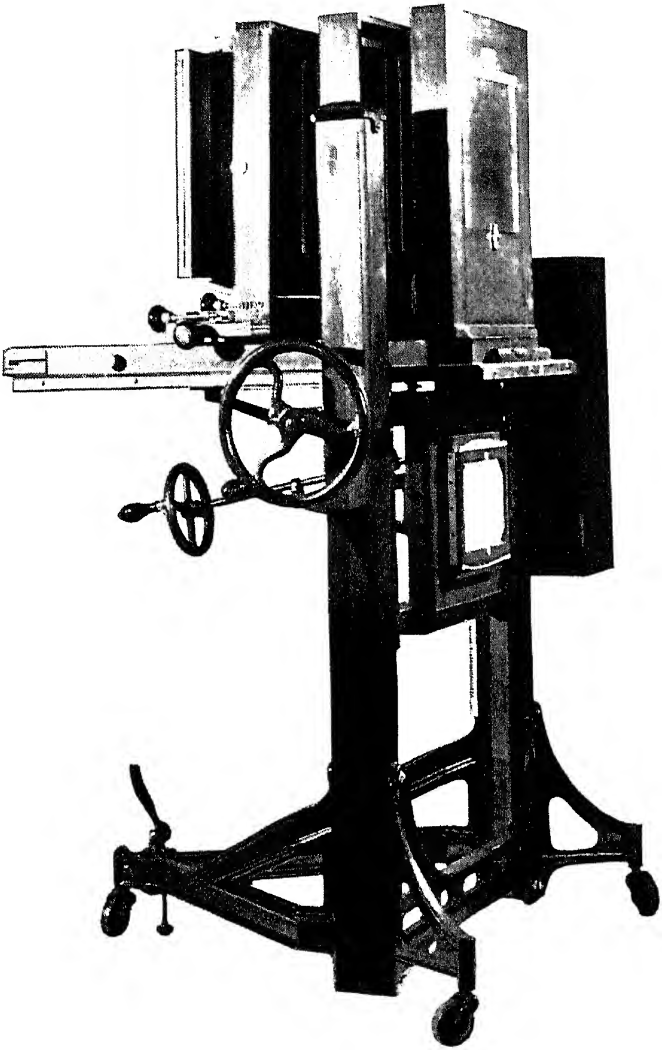
FIG. 7.—VIEW CAMERA



By courtesy of The Agfa Ansco Company

FIG. 8.—STUDIO CAMERA

known being the Exakta and the National Graflex. These are reflecting cameras, as discussed on page 22, being equipped with focal-plane shutters, the former giving speeds from 12 seconds to 1/1000 second, the latter from 1/30 to 1/500 second. The former may be obtained in either 1⅝×2½ or 1×1½ inch size, the latter in 2¼×2½ inches. A wider range of accessories is available for the former, including a variety of lenses of different focal lengths.

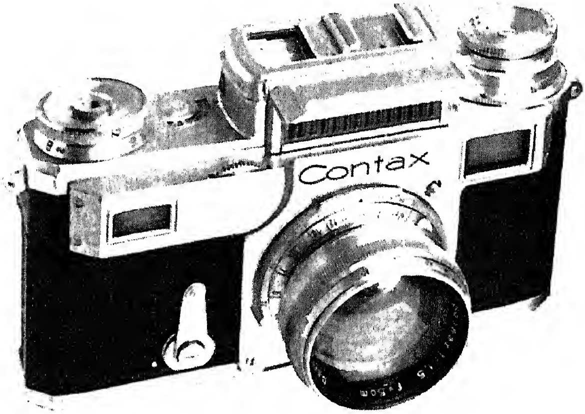
(3) *The Folding Film Miniature.*—These instruments are, in general, simply smaller models of the ordinary folding film camera, ranging in negative size from 1×1½ to 2¼×3¼ inches, using between-lens shutters, and having lenses ranging in speed from F/2 to F/4.5. They vary widely in price, the more expensive ones being usually equipped with direct-coupled range finders, either of the type described above, or of the split-image type, in which the principal object, when out of focus, is seen divided along the median line, the two halves being brought into coincidence as the lens is brought into focus. This type of range finder is much easier to use in a weak light, or by a person with imperfect eyesight, than the coincident image type. No special accessories or lenses are available for these cameras.

(4) *The Twin-Lens Type.*—This is a reflecting camera, available in various sizes from 1×1½ to 2¼×2¼ inches, but instead of using a swinging mirror and focal-plane shutter, it has the lens

mounted in a high-grade between-lens shutter giving speeds from 1 to 1/500 second, focussing being by means of a second lens that projects the image on a fixed mirror which reflects it to a horizontal ground glass. The advantages of this type of design as compared to the usual reflex type are: when moving objects are being photographed, the time lag due to the swinging mirror (which may amount to as much as 1/5 second) is avoided; the between-lens shutter is preferred to the focal-plane by many photographers; and it is possible to use a viewing lens which is faster than the taking lens, thus making it easier to focus in a weak light. The disadvantages are: the additional cost of the viewing lens; exposures shorter than 1/500 second are not possible; there is a slightly (though very slightly) greater chance of the camera getting out of adjustment; and unless special precautions are taken in the design, parallax will occur when focussing on very near objects.

Many cameras of these several designs are precision-built instruments, and can be depended on to give first-class results when properly used. The same cannot be said of the numerous cheap cameras which have been put on the market in order to trade on the reputation of the better miniature instruments.

Broadly speaking, the miniature cameras are designed for extreme portability. They are light and compact, and are highly desirable for record work and to a considerable extent for scientific photography, but they are not to be recommended to the

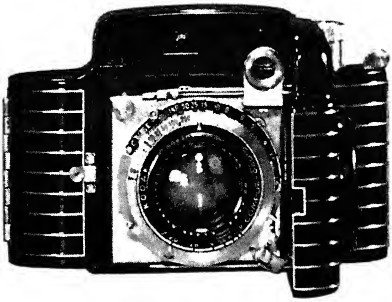


By courtesy of Carl Zeiss, Inc.

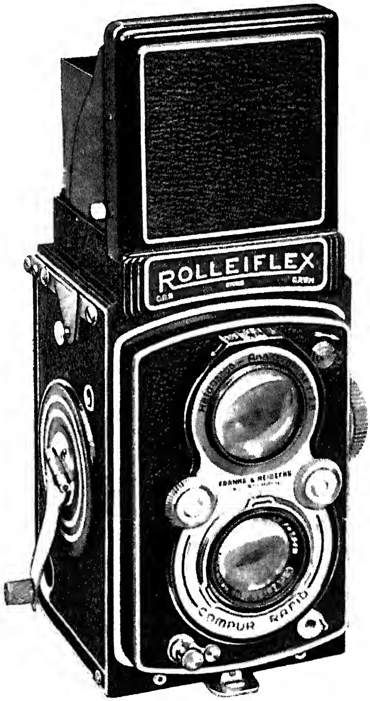
FIG. 9A.—TYPE 1

By courtesy of the Photo Marketing Corporation

FIG. 9B.—TYPE 2



By Courtesy of the Eastman Kodak Company
FIG. 9C.—TYPE 3



By Courtesy of Burleigh Brooks, Inc.
FIG. 9D.—TYPE 4

pictorial worker unless he has had a great deal of experience with a camera having a large focussing screen. This is said with full knowledge that much fine pictorial work has been done with miniature cameras.

When considering the purchase of a miniature camera, it should be borne in mind that although the light-passing efficiency of the focal-plane shutter is somewhat higher than that of the between-lens shutter (usually in the neighborhood of 80% of the marked time, as compared to 65%) a camera using a between-lens shutter can be held in the hand for much longer exposures than one using the focal-plane shutter. This is because the light-passing time of the former is nearly the same as the total exposure, whereas with the latter the light-passing time is about ¼ or 1/5 the total travel time of the slit. Consequently, when giving, say, 1/25 second exposure, it is merely necessary to hold the camera still during 1/25 second with the between-lens shutter, whereas with the focal-plane shutter it must be held rigid during 1/5 to 1/6 second, something that is difficult to do. This objection applies chiefly to the small, light instruments; with a heavier camera, such as the Graflex, the inertia of the camera is so great that relatively long exposures can be given in the hand.

Since miniature negatives must almost invariably be enlarged, and are often greatly enlarged, it is necessary that they be sharply defined. This means that the camera must be held absolutely still during the

exposure, and the technique of holding a miniature camera and making an exposure is precisely the same as that of rifle shooting. Spread the feet as widely as is perfectly comfortable, and plant them solidly; grasp the camera in both hands, and rest the arms against the body; when ready to expose, draw a moderately deep breath, let it about half out, and hold the breath for a few seconds; while holding the breath, secure the final aim, and press the shutter release, not by jabbing with one finger, but by closing the whole hand *slowly*. If this is done, practice will make it possible to give astonishingly long hand-held exposures, even up to a full second.

The writer is frequently asked: "What camera shall I buy?" The only possible answer to this question is: "Decide what type you wish, depending on the kind of work you want to do, then buy the most expensive that you can afford. There are so many ingenious minds at work on camera design, and marketing competition is so keen, that the difference lies mainly in accuracy of construction and in the number of attachments available; broadly speaking, in cameras as in many other things, you get just about what you pay for."

There are many standard makes of each of these types, but so far as the writer knows there is none which cannot be recommended as regards construction. The camera should, except in the case of the box, folding film, or miniature type, be purchased without a lens, since the manufacturers almost in-

variably fit lenses of too short focal length for pictorial work, and do not furnish objectives of the type most useful to the artist except on special order.

As already indicated, the writer would advise that the student begin with a view camera, 8×10 or 6½×8½, and when experience in composition has been gained procure in addition either a miniature or one of the reflex type, 4×5 or 3¼×4¼, since the latter, being more portable and easily operated, will often be of use when the larger camera would have to be left at home. In addition, the smaller camera of standard manufacture will be found of great value when photographing children or objects in motion, so much so that many professional portrait workers use it exclusively for this purpose.

The present-day miniature camera is ideally adapted to secure records of transient or fugitive aspects of life. The speed with which it can be brought into action, the great depth of field resulting from the use of lenses of short focal length, the extreme rapidity of modern emulsions, the fast lenses and shutters available, and the possibility of great enlargement from fine-grain emulsions, all combine to make the miniature camera nearly the perfect instrument for this class of work. As a result, there has grown up a school of camera users who profess to believe (and in most cases actually do believe) that the older form of pictorial expression is permanently out-moded, and that true pictorialism lies in seizing these fugitive incidents and aspects of the passing

show. Such workers decry the more thoughtful, leisured pursuit of beauty and of emotional expression, even going so far as to express contempt for beauty when compared to the striking and arresting phases of our surroundings; they will not work over a subject in order to achieve the ultimate pitch of perfection, but rest content with a half-good result; they deify technique above thought; and they loudly declaim that photography is not an art, that the camera is an instrument for recording the objective, not for expressing the subjective. "We are not artists," they say, "nor do we wish to be. We are photographers of life; our ambition is to capture and to record the passing show." And it must be granted that they often display great ingenuity and skill in the pursuit of their ideal.

But the present writer cannot sympathize with this attitude. True art does not lie in merely recording the ephemeral aspects of our surroundings, but in so viewing and synthesizing these aspects that the synthesis becomes an expression of the deeper thoughts and emotions which are the springs of action. That the camera can achieve this higher purpose, and in many cases can do so far better than any other form of graphic art except, possibly, literature, has been amply proven by more than one great photographer. It is for those workers who aim at this finer and more thoughtful expression of psychic values that the present book is written, and it is for this reason that, although the various types of miniature camera are

described and their many excellent qualities are unhesitatingly admitted, the serious worker is advised to postpone buying such an instrument until he has had much experience with the more flexible though less rapid type of camera. When this experience has been gained, the miniature camera becomes an exceedingly valuable tool in the hands of the pictorial worker; but until then there is grave danger that it may lead him aside into the easier, more objective, and more ephemeral expression.

CHAPTER II

The Lens

WAVE THEORY OF LIGHT.—If we stand beside a pond of still water and throw a stone into it we shall see a series of waves passing out in concentric circles from the center of disturbance. If there be a chip or a leaf floating on the surface it will be apparent, on watching this object, that there is no forward motion of the water itself (unless the stone be so large relatively to the pond as to cause a marked displacement of the water) but that the individual molecules simply rise and fall in a vertical direction, each communicating its motion to the next, so that the wave travels forward. The simplest theory which explains satisfactorily the phenomena that concern the photographer is the one which regards the propagation of light as being due to a similar wave motion in the luminiferous ether, an invisible, imponderable substance pervading all matter, the wave motion originating in any self-luminous body.[1] The motion of water particles is represented diagrammatically in Figure 10, which shows two complete waves, but it

[1] One theory regards the propagation of light as consisting of a series of irregular pulses which are transformed into a simple harmonic motion on encountering any material obstacle, but since we are dealing with light only after it has encountered such obstacles the above statement may be taken as correct.

must be understood that whereas the water particles vibrate only vertically,[2] at right angles to the axis of translation of the wave, the ether particles vibrate at right angles to this direction, and in all azimuths to it, that is, vertically, horizontally, obliquely, etc. The distance, A—B, from the crest of one wave to that of the next, or, more generally, from any point in a wave to the point which is in the same phase in the next wave, is known as the wave length. Unless artificially deflected, light tends to travel in straight lines, but it may be reflected or refracted, that is, bent, and it is upon this principle of refraction that the action of a lens depends.

Refraction of Light.—Consider now the case of a ray of light, traveling in a straight line, and en-

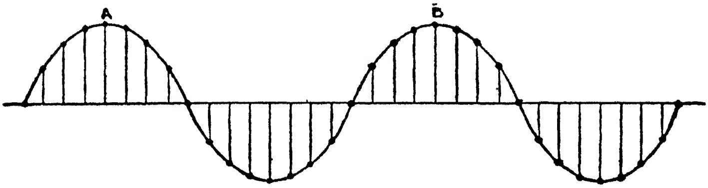


FIG. 10

countering a plane, parallel-sided sheet of glass. If the ray meets the glass normally it will simply be retarded, since light travels more slowly in a dense medium than in a rarer one, but if it meets the glass at any angle other than a right one the edge which first reaches the glass is retarded more than the other, since the latter is still traveling in air. On

[2] Actually, in small vertical circles.

emerging from the glass the reverse takes place, and the ray resumes its former direction, having merely been displaced laterally (Figure 11). If, however, the

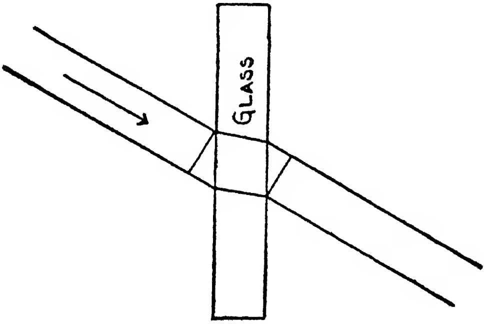


FIG. 11

faces of the glass are not parallel, the ray is refracted differently, as shown in Figure 12, where a prism of glass is represented. Here the edge B—B′ is re-

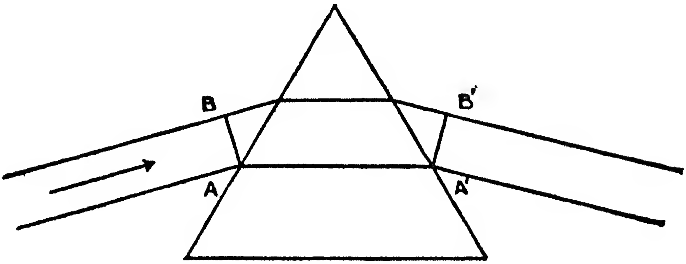
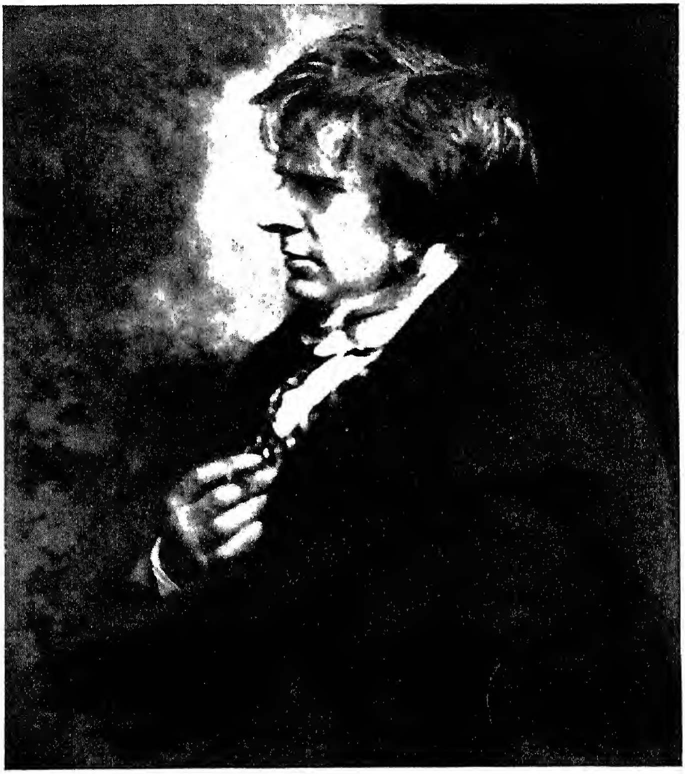


FIG. 12

tarded less than the edge A—A′, so that the ray is bent toward the base of the prism, and if sufficiently produced will meet the produced base at some point,



SELF-PORTRAIT
BY DAVID OCTAVIUS HILL
From a Gum-platinum Print by
Alvin Langdon Coburn

the distance of this point from the prism depending on the angle of the prism, the kind of glass of which it is made,[3] and the angle at which the incident ray meets the prism.

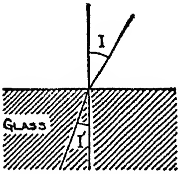


FIG. 13

Every point of every natural object sends out rays of light in all directions, either originating in the object or reflected by it, and in ordinary photographic work those rays which reach the lens may be considered parallel, since the diameter of the lens is usually small compared to the distance which the rays travel before reaching it. If, now, two prisms be placed with their bases together, as in Figure 14, the two rays, if equidistant from the axis, will obviously meet on the other side of the prisms, and will form an image of the point from which they come. Since a spherical surface (the only kind which can be accurately ground except at a prohibitive expense)

[3] The extent to which the ray is bent depends on the refractive index of the glass, and the refractive index is defined as follows. If we measure the angle, I, which a ray of light incident upon a transparent plane surface makes with the normal to the surface, and the angle, I′, which the ray makes with the normal after refraction, it will be found that the ratio of the sines of these angles is constant for a given substance. This ratio,

$\frac{\sin I}{\sin I'}$ is called the refractive index of the substance.

may be considered as made up of an infinite number of triangles, it follows that all rays of light emanating from a point and falling on a lens will be converged by the lens and will form an image of the

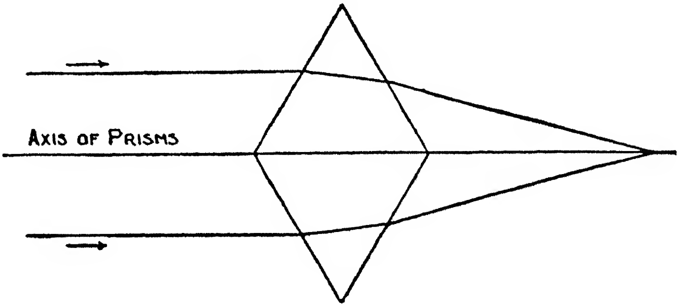


FIG. 14

point from which they come, and this is the case for all points of the object, the sum of the images of the points constituting an image of the object. Since the degree of refraction is a fixed function of the quality

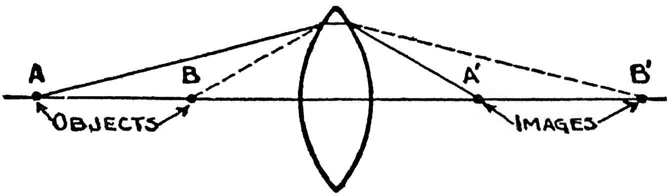


FIG. 15

of the glass and the curvature of the surface, it follows that rays meeting the lens at a more acute angle than others will emerge at a more obtuse one, this

being the reason for the necessity for setting the ground glass farther from the lens when focussing on a near object than when focussing on a more distant one. A consideration of Figure 15 will make this clear.

FORMATION OF THE IMAGE.—We have seen that a lens forms an image of an object placed in front of it, but for the sake of clearness this is illustrated in Fig-

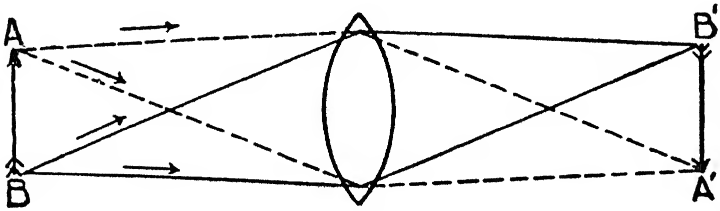


FIG. 16

ure 16, where two rays from each of two points are considered. This also indicates the reason for the inversion of the image on the ground glass.

FOCAL LENGTH OF A LENS.—The focal length (often incorrectly called focus) of a lens is the distance from the lens to the point at which rays originally parallel meet after refraction, this definition being of importance.[4] The focal length is illustrated in Figure 17, and depends on the design of the lens, that is, the curvature of the surfaces and the kind of glass used. In a double lens, which consists of two single lenses mounted at opposite ends of a barrel,

[4] This is not strictly correct, since it assumes that the nodal planes coincide with the central plane of the lens, which is true only in the case of an infinitely thin lens, but for practical purposes it may be considered to be the case.

the focal length must be measured from the optical center of the combination, and this point usually coincides with the diaphragm, so that the focal length may be measured from this point, the determination in this manner being sufficiently accurate for practical purposes. To find the focal length of a lens, set the camera up and focus as sharply as possible, at full

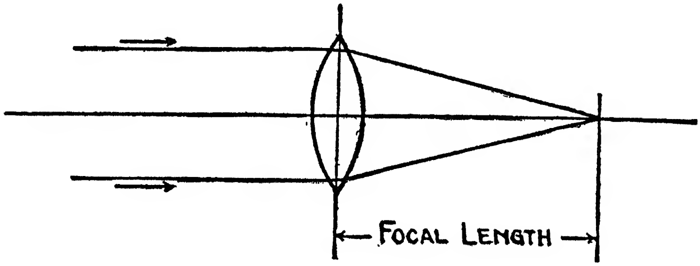


FIG. 17

aperture of the lens, on some object more than a hundred feet away. Measure the distance from the ground glass to the lens, if a single lens, or to the diaphragm, if a doublet. This will be the focal length of the lens, and an error of 1/8 or even 1/4 inch will not be of importance to the pictorialist. This method is not applicable to telephoto lenses.

DISPERSION OF LIGHT.—If a ray of white light be allowed to fall on a prism, as in Figure 18, it does not emerge as a ray of white light, but as an elongated band of different colors, thus proving that white light is a compound. This separation is known as dispersion, and it has been found to be due to the fact that white light does not consist merely of rays of

one definite wave length, but is a synthesis of rays of many lengths, the waves of different lengths being refracted differently, and it has also been found that the rays of shorter wave length are refracted more than those of greater length. Different portions of the retina are sensitive to waves of different lengths,

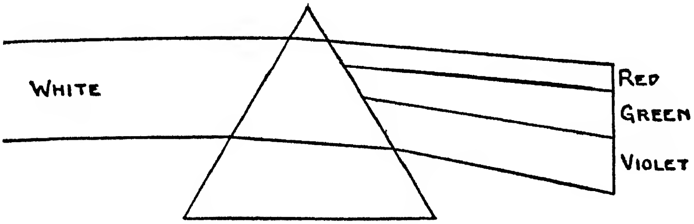


FIG. 18

those waves from 4000 to 5000 A. U.[5] in length giving rise to a sensation of violet, those from 5000 to 6000 to one of green, and those from 6000 to 7000 to one of red, the mixture of these in proper proportions causing a sensation of white.[6]

CHROMATIC ABERRATION.—It will be apparent that a lens which analyzes white light cannot give a sharp image of any point which sends out rays that are not purely monochromatic, and this defect is known as chromatic aberration, being illustrated in Figure 19, where the violet rays, being of shorter wave length than the green, are more refracted, and are brought to a focus nearer the lens than the latter, these in turn being focussed nearer the lens than the red.

[5] A. U. is the abbreviation for Angström unit, the unit being 1/10,000,000 of a millimeter.

[6] These figures are approximate only.

Since the focal length of a lens depends fundamentally on the curvature of the surfaces, and the dispersion depends fundamentally on the type of glass, it follows that by combining two kinds of glass of different dispersive powers, ground to different focal lengths, it is possible to produce a lens which will converge the rays but will not disperse the different wave lengths, and such a lens is said to be achro-

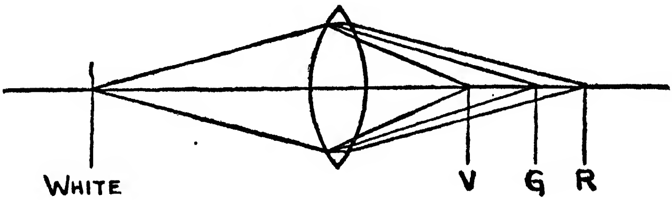


FIG. 19

matic, or free from chromatic aberration. It should be noted that no lens which consists of a single piece of glass, such as a spectacle lens, or the Struss Pictorial Lens, can be achromatic.

SPHERICAL ABERRATION.—This optical error is due to the fact that a lens having surfaces which are portions of a sphere converges the rays passing through near the margins and those passing through near the axis at different distances from the lens, as is illustrated in Figure 20. This has nothing to do with dispersion, the present error manifesting itself with monochromatic as well as with compound light. Spherical aberration depends fundamentally on the curvature of the lens surface, and may be either positive or negative, that is, the marginal rays may be

brought to a focus either nearer to or farther from the lens than the axial. It is possible to grind lenses of the same focal length in a variety of shapes, and spherical aberration is corrected by combining two lenses of different focal lengths in which the error is of the same magnitude but opposite in sign, thus producing a lens which converges rays of light but has no outstanding spherical aberration. It should be noted that if the two surfaces of the lens have different radii of curvature spherical aberration is less

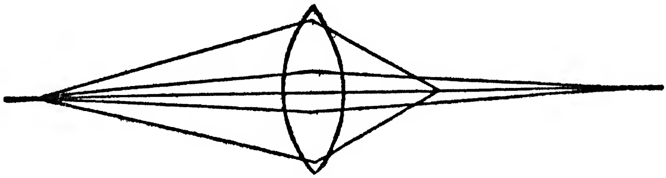


FIG. 20

when the more deeply curved one (the one having the smaller radius) is toward the parallel rays than in the reverse case, as is illustrated in Figure 21, where A and B show the same lens, turned in different directions. Hence, if the combinations of a lens are removed for cleaning, or if a single lens is taken out of the barrel, care must be used to see that it is replaced in the proper manner.

Curvature of the Field.—Curvature of the field is that defect in which the image of a plane surface is projected, not as a flat plane, but in a saucer-shaped envelope, the edges of the image being usually nearer the lens than the center. Obviously, if a lens

has this defect a flat plane cannot be brought to a focus on the plate, for if the center is sharp the edges will be out of focus, and *vice versa.* The best approximation to a focus is got by setting the plate midway between the focal plane of the center and that of the edge, when the diffusion of center and edge will be

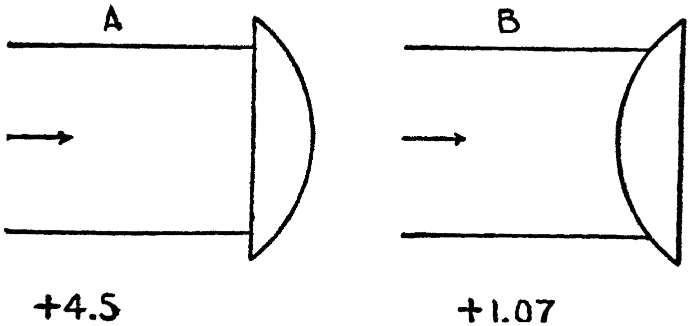


FIG. 21

only half what it would be for either if the other were sharply focussed. Curvature of the field is corrected by designing the lens so that the focal length is somewhat greater for the edges of the field than for the center.

FLARE.—Flare is not, properly speaking, an inherent optical defect, but is due to faulty design. When a ray of light passes from one medium to another of different density (or, more correctly, of different refractive index) a portion of the light is reflected from the junction of the two media. Hence, when light falls on a lens part passes through and part is reflected from the second surface. This last

part may be reflected again from the first surface and again pass through the lens, falling on the plate at a point different from that where the original ray falls. If these secondary rays converge near the plate we may have a definite secondary image of the originating point, this being the worst form of the defect, and being called flare spot, but if they converge at a point remote from the point of convergence of the principal rays they may simply cause a general il-

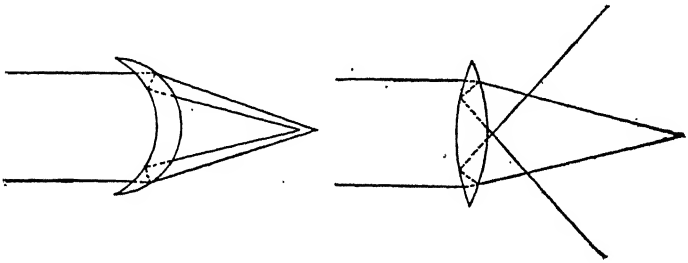


FIG. 22

lumination of the plate, resulting in slightly less brilliant negatives than if flare were absent. These two conditions are illustrated in Figure 22. It will be apparent that an anastigmat, which has three or five, or even more, reflecting surfaces, will be more likely to show flare than a single lens, which has but one such surface,[7] and this fact is of importance to the pictorialist, who does much of his work against the light, flare being, of course, more conspicuous when working in this manner than when no very brilliant

[7] A cemented surface does not cause flare, since the refractive index of Canada balsam (which is used to cement the elements together) is nearly that of glass.

light is included in the field of view. A lens hood, shielding the lens from extraneous light, often helps to minimize this fault.

DISTORTION.—Distortion is unavoidable in a single lens, and is that defect which results in straight lines near the edges of the field being rendered not as

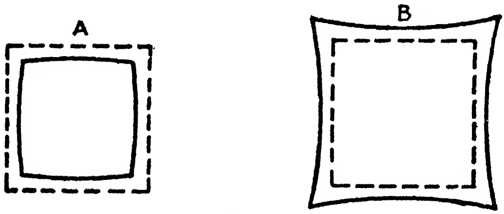


FIG. 23

straight, but as slightly bowed. If the diaphragm is in front of the lens (that is, between the lens and the parallel rays) the bowing will be convex (barrel-

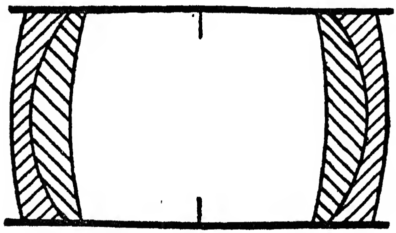


FIG. 24

shaped) as in Figure 23A, whereas if it is behind the lens the distortion will be concave (pincushion) as in Figure 23B. The dotted lines show the position which the image should have. Distortion is corrected by mounting two similar lenses at opposite ends of a

barrel, as in Figure 24, with the diaphragm symmetrically placed between them, when the barrel-shaped distortion of the one balances the pin-cushion distortion of the other, and such a lens is known as rectilinear. If the combinations are not similar, the diaphragm is placed nearer one than the other, for the farther the diaphragm is from the lens, the greater the distortion. Hence, if the combinations of an asymmetrical objective are removed from the mount, care must be taken to see that they are replaced in their proper relative position. Since distortion does not exist in lines coinciding with the axes of the plate, and grows progressively worse toward the edges of the field, it follows that if the lens has a focal length which is large relatively to the size of the plate used, so that the plate occupies only a small portion of the entire image projected by the lens, distortion will not be excessive, and in any case it will not appear unless the picture includes straight lines, such as are found in architectural subjects, so that a lens having distortion may be used with perfect satisfaction for landscape and portraiture.

ASTIGMATISM.—Astigmatism is that defect in which bundles of rays passing obliquely through the lens near the margin are converged, not to points, but to straight lines. Each such bundle is converged to two straight lines at different distances from the lens and at right angles to each other, or, rather, it is converged to a line, and after passing the point of convergence it diverges again to another line. Astig-

matism is difficult to illustrate graphically, but may be understood by anyone who will roll up a truncated cone of paper and pinch the small end to a straight line, afterward pinching the cone to another straight line at right angles to the first and at some distance from the end. The straight lines represent the projection of a point of the object, whereas if the lens were free from astigmatism this projection would be represented by rolling the paper so as to form a complete cone, the small end being a true point. It should be noted that astigmatism appears only at the margins of the field, so will not be noticeable if the lens is of great focal length relatively to the plate used. The practical result of astigmatism is to render it impossible to focus simultaneously on vertical and horizontal lines in the same plane and lying near the edges of the field, so that if the image of a tree, for instance, comes close to the edge of the plate the trunk will be sharp and the branches blurred, or *vice versa,* but it will not be possible to get both sharp at once, except by using a small diaphragm.

TYPES OF LENS.—*Spectacle and Single Meniscus.*— The spectacle lens is simply a double convex piece of glass, such as an ordinary pocket magnifying lens, and the single meniscus is a concavo-convex lens with different radii of curvature for the two surfaces. There was formerly on the market an objective of the latter type, the Struss Pictorial Lens, especially designed for pictorial work, such a lens possessing all

possible errors, and giving, as a result of its optical defects, a very soft and pleasing quality of definition. These lenses may still occasionally be picked up secondhand, or can be made to order by any good manufacturer of optical instruments.

Single Achromatic.—As indicated above, the single achromatic lens consists of two pieces of glass cemented together, and so designed that the yellow (green+red) rays are brought to a focus at approximately the same distance from the lens as the violet, these latter being the most active chemically, whereas the yellow are the most luminous to the eye. Such a lens is generally partly corrected for spherical aberration, and is not likely to show flare, but has all the other optical errors. In general it gives somewhat sharper definition than the simpler types, but there are a number of pictorial lenses in which either chromatic or spherical aberration is only partly corrected, so that a soft definition is obtained. It must be understood that in the objectives named, as well as in the Struss lens, the lack of correction is intentional, such lenses being known as "soft-focus" or "pictorial" lenses.

Rapid Rectilinear.—This objective consists of two single achromatics mounted as shown in Figure 24, and is usually corrected for chromatic and spherical aberration, and, of course, for distortion, but has curvature of the field and astigmatism, and is more likely to show flare than the simpler lenses. The result of mounting two similar lenses in this manner

is that the combination has half the focal length of either of the elements, so that if a long-focus lens is desired, one of the elements may be removed from the barrel and the other used alone. This fact will be referred to later, in discussing diaphragms.

Anastigmat.—This is corrected for all optical errors, but may show flare, the writer having seen an objective of this type from one of the most favorably known makers which possessed a marked flare spot, and for this reason, if for no other, would be useless for pictorial work.

It must be understood that it is impossible to correct absolutely for an error, that is, to make the lens render the image of a point of light as a true point, over the entire field of the objective, and an approximation is all that can be expected. The result of any optical error is to make the image of a point appear as a circle of appreciable diameter, and the purpose of the designer is to reduce the diameter of such a circle, known as a "circle of confusion," to a size which will be inappreciable to the unaided eye, sometimes as small as 1/2000 inch. Further, this cannot be attained over the entire field of the lens, so the designer endeavors to attain his ideal over as large an angle as possible. Hence, when a lens is said to be corrected for any fault, it means that the circles of confusion due to this error do not exceed the specified diameter over the size plate for which the lens is listed. If used on a larger plate the error will become apparent.

There are other types of lens than those mentioned above, such as the periscopic, which consists of two single meniscus lenses mounted as shown in Fig. 24; the Petzval portrait lens, which has great speed and microscopic definition over a small angle, but has little covering power, so that the objective must be of great focal length as compared to the plate; and the apochromat, which is the highest type of anastigmat: but the first two are seldom met nowadays and the last is of value only to the process worker or microscopist, or, in general, to those workers who require extremely fine definition.

So far as definition is concerned, the objectives enumerated are arranged progressively in order of increasing accuracy, the single lenses giving the softest drawing and the anastigmat the most exact. Since the normal eye has chromatic and spherical aberration, and in many cases astigmatism exists as an abnormality, it follows that an objective which gives microscopic definition cannot render objects as they appear to the observer.

The pictorialist generally wishes to represent objects in this manner, and it will be found that for his purpose the most useful lens is in general either the single meniscus, such as the Struss, or the single achromatic, either of these being used at about F/5.5. Examination of the works of great artists shows that portrait painters may in general be considered to have used either a rapid rectilinear or a single achromatic (though Carrière and Whistler

used, in the main, softer definition) and that landscape and figure painters commonly used, so to speak, a single achromatic or a single meniscus. It is of course possible to use an anastigmat and to soften the excessively harsh definition by various means; but there is little point to using an expensive, highly corrected lens and then destroying its corrections, when for one-tenth or one-twentieth the money one can get an objective which will give the desired effect in the first place. However, if the photographer wishes to take advantage of the extreme speed of the modern anastigmat, and at the same time produce soft-focus negatives, he can employ a diffusion disc, this being a disc of high-grade glass, arranged to slip on the lens in the manner of a ray-filter, but having concentric circles cut in one face. This diffuses the light which reaches the lens, producing an effect very nearly the same as that given by an uncorrected lens. A "soft-sharp" screen is also available, this being arranged to slide past the lens, the effect being graduated through the screen, so that it is not necessary to use different discs in order to get varying degrees of diffusion. Either of these attachments gives excellent results, and either can be used in enlarging as well as in making the original negative.

DIAPHRAGMS.—It now becomes necessary to consider the matter of diaphragms. These are devices of various sorts, so arranged that a portion of the rays which would ordinarily pass through the lens may be excluded, the proportion excluded depending on

the size of the aperture in the diaphragm. The types of diaphragm are (1) rotary, consisting of a metal plate with circular holes of different sizes, so arranged that by rotating the plate the desired aperture is brought in front of the lens; (2) Waterhouse, consisting of several plates with different sized holes, the desired plate being slipped into a slot in the lens barrel; (3) iris, consisting of a number of thin curved plates, overlapping and arranged so that the rotation of a ring causes the plates to move toward a common center, thus diminishing the size of the aperture. In practice, only the third type is likely to be met to-day. In single lenses the diaphragm is practically always placed in front of the glass, and in compound lenses between the combinations. Since spherical aberration and astigmatism are due to the marginal rays it follows that if these rays are excluded the errors disappear, and it will be obvious that if only the axial rays are used in forming the image these will approach the plate at a more acute angle than the marginal rays (see Figure 19) so that chromatic aberration will be less apparent, curvature of the field being at the same time rendered less conspicuous for the same reason. Hence, all optical errors except distortion and flare may be corrected by the use of a small stop,[8] and it follows that the only advantage of the anastigmat is that it gives fine

[8] There is a pseudoflare which results from the reflection of light by bright surfaces inside the lens barrel, and this may often be diminished by the use of a small stop. Obviously, however, the best way to prevent this form of flare is to have the inside of the barrel properly blackened.

definition at a larger aperture, and consequently with briefer exposures, since the more light that passes through the lens, the less the time required for it to produce the desired chemical effect on the plate.

DEPTH OF FIELD AND DEPTH OF FOCUS.—If the camera be set up and focussed as sharply as possible on some object a short distance away it will be found that objects slightly nearer and slightly farther away are also in focus, so far as can be seen by the unaided eye. The distance from the nearest to the most remote of the objects apparently sharp is known as the depth of field (often incorrectly called depth of focus). It will also be found that if a given object is sharply focussed on it is possible to move the ground glass and the lens slightly nearer together or farther apart without visibly impairing the definition of the object in question. The distance through which the ground glass (or the lens) may be moved is known as the depth of focus. Obviously, the depth of field and depth of focus depend on the manner of observing the image, since if a magnifying lens is used to examine the image on the ground glass faulty definition becomes more apparent than it would be to the unaided eye, the circles of confusion being magnified. The use of these terms therefore implies that no magnifier is used.

Depth of field and depth of focus are functions of the focal length of the lens and of the size of the stop used, being inversely proportional to these charac-

teristics. That is, they are greater in a short focus lens than in one of greater focal length (which fact makes possible the use of extremely large apertures on miniature cameras) and are greater with a small stop than with a large one, this latter fact being due to the circumstance that the axial rays converge at a more acute angle than the marginal. Hence, all lenses of the same focal length and the same aperture are identical as regards depth of field and of focus, the frequent claim of the manufacturer that his lenses have great depth meaning simply that they are so well corrected that one of relatively short focal length may be employed with a given size of plate. It should be noted that the soft focus lens, or, in fact, any uncorrected objective, has greater apparent depth, both of field and of focus, than the more highly corrected lens, since if no plane is sharply defined the difference in definition between the one which is most accurately defined and those which are out of focus is less apparent than when one is microscopically sharp.

In fixed focus cameras, lenses of short focal length and small aperture are employed, the result being that the depth of field extends from a point about six feet from the camera to infinity, thus obviating the necessity for focussing. Such cameras are sometimes called "universal focus."

DIAPHRAGM MARKINGS.—It is obvious that if a small aperture is used less light will reach the plate in a given time than with a large one, and since the

sensitive emulsion has some inertia, that is, requires some light to produce any chemical action whatever, a longer exposure will be necessary if a definite effect is to be obtained. The markings of the apertures furnish an indication of the relative exposures necessary with the various stops, and there are two principal systems of marking in use, the F system and the Uniform System (abbreviated to U. S.). In the former the number expresses the fraction which the diameter of the aperture is of the focal length of the lens, that is, F/8 means diameter of aperture $= \frac{\text{focal length}}{8}$, F/11 means diameter of aperture $= \frac{\text{focal length}}{11}$, etc. Since the time of exposure varies inversely as the area of the stop, and since the areas of circles are directly proportional to the squares of their diameters, it follows that the ratio of exposures required with different stops is the ratio of the squares of the F numbers. Thus, F/16 will require four times as much exposure as F/8, since $(16)^2 = 256$ and $(8)^2 = 64$, and $\frac{256}{64} = 4$. Stops are usually marked in such a series that each requires twice as much exposure as the next larger, the F series being F/4, F/5.6, F/8, F/11.3, F/16, F/22.6, F/32, F/45, F/64, etc. Intermediate numbers such as F/6.8, F/7.7, are sometimes used, when these represent the largest aperture of the lens. In the Uniform System

F/16 is taken as the arbitrary unit, and is called U. S. 16, the other apertures being so marked that the ratios of the exposures are directly as the ratios of the numbers, the actual diameters of the openings, in inches, remaining the same as in the F system. The table below shows the relation between the two systems, and the exposures required:

F System	Uniform System	Relative Exposure in Seconds or Minutes
4	1	1
5.6	2	2
8	4	4
11.3	8	8
16	16	16
22.6	32	32
32	64	64
45	128	128

There are other systems, but they are comparatively little used, and even the Uniform System is now practically extinct.

It should be noted that when one combination of a symmetrical lens is employed the stop markings no longer represent the true values of the apertures. Thus, suppose the case of a rapid rectilinear lens of eight inches focal length, working at a maximum aperture of F/8. When one combination only is used the focal length becomes sixteen inches (8×2). Since the aperture of the whole lens is F/8 and the focal length eight inches, it follows that the aperture has a diameter of one inch, and the working aperture of the single combination becomes F/16 (16/1=16). Hence the single combination will require four times the exposure of the doublet.

Speeds of Lenses.—Returning now to the matter of lenses, it has been explained that a high grade lens is one which has been so well corrected for optical errors that it will give fine definition at a large aperture, but the same result may be attained with an uncorrected lens by stopping down, and the following table gives a general idea of the largest apertures at which different types of lens work, though it must be understood that these figures are not fixed, but vary with different manufacturers:

Type of Lens	Sharp Definition	Pictorial Work
Spectacle and single meniscus	F/16	F/5.6
Single achromatic	F/11	F/5.6
Rapid rectilinear	F/8 (sometimes F/11, more rarely F/4)	
Anastigmat	Varies greatly. Seldom smaller than F/7.7 or larger than F/2	
Soft focus	F/16	F/5.5 for single lenses and F/4 for doublets

It is possible for anyone to educate himself to prefer abnormally sharp definition to the normal quality as seen by the eye, and a certain group of photographers have taught themselves to do this; further, through what William James called "the will to believe," they have convinced themselves that they actually do see objects as sharply as does the anastigmat, though in point of fact this is a physical impossibility. Still further, many of this school, in their passion for extreme sharpness, stop down to F/45 or F/64—even, in some cases, to such absurd stops as

F/128 or F/256—believing that by so doing they are improving definition. But in this instance, as in the former, they are deceiving themselves, for it should be noted that stopping down to improve definition cannot be continued indefinitely. For every lens there is an optimum aperture at which definition is sharpest, this optimum depending partly on the design of the lens and partly on the focal length. With the 2-inch (50 mm.) lenses that are used on miniature cameras this optimum is usually around F/6.3 or F/8, and for a 10-inch or 12-inch lens it is likely to be in the neighborhood of F/11 or F/16. If larger apertures are used, the definition is impaired by optical errors, and if the lens is stopped down below the optimum, the phenomenon of diffraction at the diaphragm becomes of importance, injuring the definition. Broadly speaking, about the smallest aperture than can be used without impairing the definition is F/45, and as a rule the lens manufacturers mark smaller openings than this only on order. This softening of definition through diffraction patterns is not usually very serious, but it exists, and photoengravers often make use of it to lose the screen pattern when they are making color-separation negatives, or even black and white reproductions, from color transparencies such as Filmcolor or Dufaycolor.

Focal Length and Perspective.—We may now take up the question of the proper focal length of the

lens, from the point of view of the artist, and, as stated in Chapter I, it will almost invariably be found that when a lens is furnished with the camera it is of too short a focal length to be desirable for pictorial work. It is generally said that a long focus lens gives better perspective than one of short focal length, but this is not quite correct, since the long focus lens merely forces the camera farther from the object in order to get a given size of image, and perspective depends on the relative distances between the planes of the object and the camera. In Figure

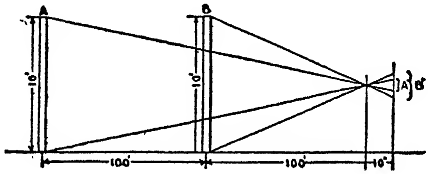


FIG. 25

25 suppose A and B to be two posts, each ten feet high, the distance between A and B and between B and the camera being one hundred feet. Suppose we have on the camera a lens of ten inches focus, then a simple proportion gives the sizes of the images, A′ and B′, of the posts, to be

10″ : 100′ : : B′ : 10′	hence B′ = 1″
10″ : 200′ : : A′ : 10′	hence A′ = ½″

That is, the image of A is one-half the size of the image of B. If, now, we use a twenty-inch lens, then in order that the image of B may be the same size as in the first case it will be necessary to set the camera

up twice as far from B, when the proportions become as follows (Figure 26):

20″ : 200′ : : B′ : 10′	hence B′ = 1″
20″ : 300′ : : A′ : 10′	hence A′ = 2/3″

That is, the image of A is two-thirds the size of that of B, and the perspective is more pleasing, being less abrupt, though it should be noted that the perspective in the first case is absolutely true, being what an observer would see if he stood one hundred feet from B. If, however, the ten-inch lens is set up two hundred feet from B the ratio of the two images will

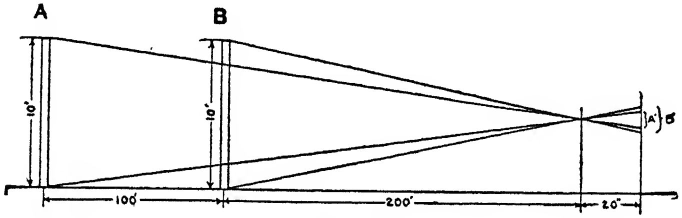


FIG. 26

be the same as if the twenty-inch lens were used, each image being half the size that it would be with the longer focus objective, and if the smaller negative be subsequently enlarged two diameters the final result will be the same in both cases, so far as perspective is concerned. It should be noted, however, that the use of a short focus lens and subsequent enlargement results in greater depth of field (and of focus) since, as stated above, the depth varies inversely as the focal length of the lens. Depth of focus is practically always desirable, especially since

films are now so generally used, for many cameras lack any arrangement for holding the film in a flat plane. Depth of field, however, is not necessarily to be desired, for it prevents the worker from emphasizing one particular plane by focusing on it more sharply than on the others. This greater depth of field is one of the chief arguments brought forward by the advocates of the miniature cameras, but each worker must decide for himself whether or not the argument is valid in his own case.

If the lens is of too short focal length it will be difficult to keep far enough from the nearest object to insure pleasing perspective, since perspective is not very apparent on the ground glass, and the tendency is to approach near enough to get the principal object of the desired size. On the other hand, if the lens is of too great a focal length it will often be found difficult, by reason of the size of the studio or the configuration of the landscape, to get far enough away to include all that is wanted. The best focal length of lens to use for general purposes with any given size of plate is found by adding the lengths of two adjacent sides of the plate. Thus, for a 4×5 plate, a 9″ lens should be employed, for 6½×8½, 15″, for 8×10, 18″, etc. This rule is purely empirical, but gives good general results, though it may sometimes be advisable to modify it somewhat. For example, if the worker is using a 4×5 plate, and wishes to do outdoor portraiture or to select small landscape bits, a 12″ lens may be better, but if he is

doing studio portraiture or wide landscapes, one of 8″ focal length may be preferable. Generally, however, a long focal length is to be preferred to a shorter one.

THE PINHOLE.—A device which is sometimes used in pictorial work, and which presents certain advantages over the lens, is the pinhole. This is made by piercing a hole from 1/50 to 1/20 inch in diameter in a thin plate, which is usually of metal, and placing this plate in the front of the camera, instead

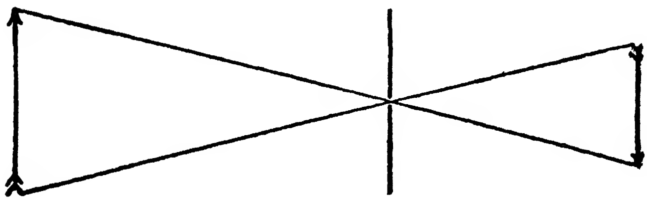


FIG. 27

of a lens, to project an image on the film. As stated above, every point of a luminous or reflecting body sends out rays in all directions, and if the pinhole were of sufficiently small dimensions only one ray from each point of the object would reach the plate, as illustrated in Figure 27, thus forming an image of the point on the sensitive surface. Since, however, the pinhole is of large dimensions as compared to a ray of light, more than one ray from each point will pass through, the practical result being a slight blurring of the image, which blurring may, however, be reduced to an amount inappreciable to the eye by

sufficiently reducing the diameter of the hole. It should be noted, though, that if the diameter of the hole is less than 1/75 inch, diffraction, or the bending of light rays in passing an edge, may cause the image to be somewhat lacking in definition, so it is not possible to secure absolutely sharp images by reducing the size of the aperture. Since the rays are not refracted, and since there are no reflecting surfaces, the pinhole is entirely free from optical errors and from flare, and for the same reason (that the rays travel in straight lines throughout) there is no focal point, the only effect of moving the film nearer to or farther from the pinhole being to alter the size of the image, and, of course, the amount included on the plate. Hence the pinhole is equivalent in including power to a battery of lenses of all focal lengths. As a corollary, the pinhole may in an emergency be used as an extreme wide-angle lens, having been successfully used with so short a bellows extension as 3½ inches on an 8×10 plate, the angle of view in that case being 142°. Of course, since the intensity of illumination falls off with the distance which the pinhole (or lens) is from the plate, the light being spread over a greater area, a negative made in such extreme circumstances will show less exposure at the edges than at the center, but this can be equalized in printing.

Since light is propagated in straight lines outside as well as inside the camera, it follows that the pinhole has infinite depth of field as well as of focus, all

objects within the field of view being equally well defined. This may be an advantage or the reverse, the former because stopping down a soft focus lens to secure depth changes the quality of definition, the latter because it is sometimes desirable, as mentioned above, to emphasize one plane by focussing on it more sharply than on the others.

The advantages of the pinhole, then, are infinite depth of field and of focus, and a very pleasing quality of definition, the amount of diffusion depending on the size of the hole. The disadvantages are the impossibility of accenting one plane at the expense of the others, and the long exposures required. More or less complicated methods of calculating the exposure required with the pinhole are given in various textbooks, but the simplest is to divide the diameter of the hole in inches by the distance which it is from the plate, and to take this as the F number of the hole with that particular bellows extension. (This, obviously, is the same method that is employed in finding the F value of a lens stop.) Thus with a hole of 1/20 inch diameter and an extension of 10 inches, the value would be $(1/20) \div 10 = F/200$. In these circumstances the exposure for a brightly lighted landscape at midday in June, using a fast film, would be about 3 seconds, whereas with a lens working at F/4.5 it would be 1/600 second. It will thus be seen that the use of a pinhole precludes the photography of moving objects and even renders it impossible to do landscape work on a windy day,

while it is entirely out of the question for general indoor portraiture. Within these limitations, however, it is a very useful instrument.

The illumination of the ground glass being very feeble when a pinhole is employed, it is difficult to locate the image on the focussing screen with the hole to be used for exposure, and it is customary to surmount this difficulty by the use of an auxiliary hole of about 1/8 inch diameter, which gives more illumination and at the same time affords sufficient definition to permit of arranging the picture.

In describing the method of making a pinhole the textbooks usually give elaborate instructions for its manufacture, these directions looking toward an accurately gauged, sharp-edged hole. The writer finds, however, that for pictorial work it is sufficiently accurate to punch a hole with a pin or needle in a piece of black paper such as plates are wrapped in, as the purpose of the more accurate method is to approximate lens definition, which is precisely what the artist wishes to avoid.

Discussion of the Soft Focus Lens.—It has been said that the primary value of the soft focus lens depends on the fact that it gives a quality of definition approximating that of the eye, but there are two other characteristics which go to make this type of objective desirable. The first is that by the use of an aperture larger than normal it is possible to obtain greater diffusion, thus aiding in the suggestion of mystery, a suggestion which is of importance in

any work of art; and the other is that such a lens, properly used, gives a vibrating quality of light which is closely akin to the psychic suggestion of

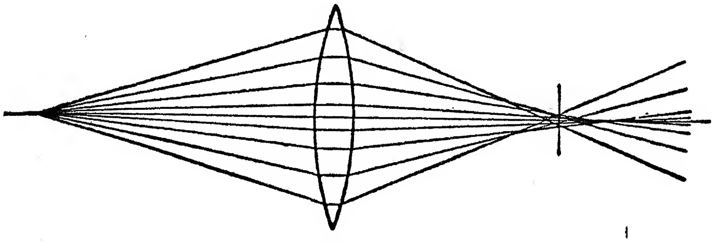


FIG. 28

sunlight. This latter characteristic requires further elucidation. In some of the earlier soft focus lenses diffusion was gained by means of spherical aberration, and if Figure 28 be examined it will be seen

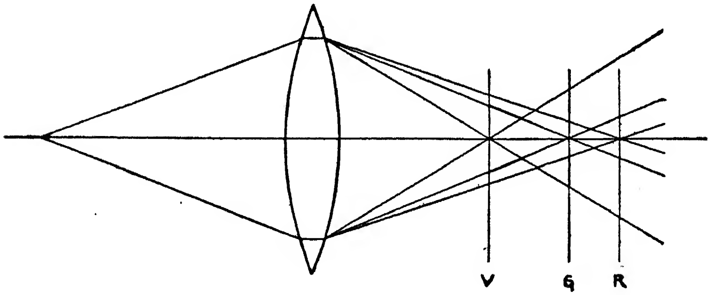


FIG. 29

that with such a lens the image of a point of light will be formed partly by the axial and partly by the marginal rays, and partly by those intermediate. Hence the image of such a point will be nearly a

uniform disc of light, provided the film be set in the plane of least diffusion; and the image of the object will be made up of a number of such discs, overlapping one another, thus causing diffusion. But the single meniscus lens, such as the Struss Pictorial lens, gains diffusion by means of chromatic aberration, and the effect is indicated in Figure 29. Here the light is analyzed, and if the film is set in the focal plane of the violet rays, which have the most intense photographic effect, the image of a luminous point will be a spot of intense light surrounded by a halo due to the less actinic green rays, the effect due to the red rays being practically zero unless a panchromatic film is used. Hence the image is made up of an infinite number of intensely illuminated spots surrounded by less intense, but moderately sharp-edged halos, and the effect is very different from that given by spherical aberration. Since the violet rays are the most active chemically and the yellow (green +red) are the most luminous to the eye, it follows that if the film be set at the visual focus the point will be due to the yellow rays and will be faint, whereas the halo, being due to the violet rays (which will be out of focus), will be intense, great diffusion resulting. If, on the other hand, the film be set at the focus of the violet rays, diffusion will be least, the halo being caused by the green rays. A rough empirical rule for obtaining the best definition at a given aperture with such a soft focus lens is to focus as accurately as possible on the principal object and

then move the ground glass nearer to the lens until the principal object just begins to be out of focus, making the exposure with the film in this position.

When using a lens having chromatic aberration a quality of definition identical with that seen on the ground glass may be secured by using a fully correcting ray-filter and focussing and exposing with it in position, since the ray-filter absorbs the ultra-violet and the superfluous violet rays, causing the residual color sensitiveness of the plate to coincide with that of the eye, and, of course, bringing the visual and the chemical foci into the same plane. The use of a ray-filter evidently presupposes the use of a color-sensitive film.

It is often stated that the same result may be secured by making an enlargement, using a soft focus lens for projection, as would be obtained if the original negative were made with a lens of this type, but this is not quite correct. In the first place, if a soft focus lens is used originally the plane focussed on is the sharpest, diffusion increasing progressively toward the distance; whereas if such a lens is used for enlarging, both image and object are flat planes, so that diffusion is uniform throughout the enlargement, regardless of the planes in which the various portions of the picture lie. In the second place, the halo which is found in the image given by a soft focus lens consists of a breaking of light into the dark spaces, so that if an enlargement is made on bromide paper from a negative, in which the lights

are represented by dense spaces and the shadows by more translucent ones, the finished print will show a dark halo surrounding the shadows and extending into the lights, the effect being very unpleasant, and not true to the manner in which the eye perceives objects. If an enlarged negative be made with a soft focus lens from a transparency this effect will of course be as it should.

Since most of the soft focus lenses on the market are of the single type, few of them being rectilinear, it follows that they cannot, in general, be used for architectural work as such with entire satisfaction. It has been pointed out, however, that if the diaphragm is between the lens and the object distortion is barrel shaped, whereas if it is between the lens and the image distortion is of the pin-cushion type, and this suggests a method whereby such lenses may be used for architectural work without representing straight lines as bowed. If an enlargement be made from the original negative, using the same lens as was employed for making the negative, and taking care to place the diaphragm between the lens and the enlargement, the pin-cushion distortion in the enlargement will correct the barrel-shaped distortion in the negative, and the final result will be rectilinear. The introduction of additional diffusion in enlarging may be prevented by stopping the lens down, since changing the size of the aperture does not affect distortion. This works well in practice, the results being all that could be desired.

Generally speaking, the soft focus lens is faster at a given aperture than the more fully corrected one, for, although all lenses of the same aperture have theoretically the same speed, an anastigmat or rectilinear usually has a greater thickness of glass than the soft focus objective, and the absorption of light in the glass may operate to make the corrected objective much slower—25 or 30 per cent in extreme cases—than the simpler lens.

CHAPTER III

Plates—Films—Ray-Filters

THE SPECTRUM.—It has already been explained that white light consists of ether vibrations of different wave lengths, the visible portion of the spectrum consisting of wave lengths from 4000 to 7000 A. U. In addition, there are known to exist waves of much less and much greater wave length, the former being known as ultra-violet and the latter as infra-

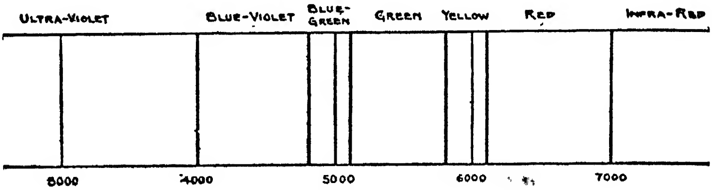


FIG. 30

red. The infra-red rays manifest themselves as heat and as Hertzian waves, and are of no importance in pictorial photography, whereas the ultra-violet have a marked chemical (photographic) action, and are extremely important. If a beam of white light be analyzed by means of a diffraction grating it will appear as an elongated band of different colors, as shown in Figure 30, where the numbers indicate the wave lengths.

Visual Luminosity.—It will be found that the visual luminosity, that is, the intensity to the eye, of these colors varies, the yellow being the most intense, while the effect falls off toward both ends of the spectrum, so that if we plot a curve in which vertical distances represent visual luminosities it will appear as in Figure 31.

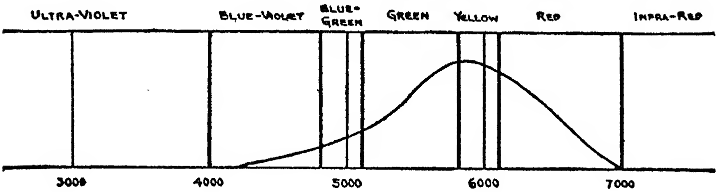


FIG. 31

Ordinary Film.—Since natural objects appear colored by reason of the fact that they absorb all light except that of a certain wave length (the wave length which gives rise to that particular color sensation), it will be apparent that if they are to be represented by photography in their correct values, that is, relative luminosities in monochrome, the sensitiveness of the film to light of the different wave lengths should be the same as that of the eye; but this is very far from being the case, for if the spectrum be photographed on an ordinary (non-orthochromatic) film and the result plotted, the curve will have the form shown in Figure 32. That is, the film is sensitive to the ultra-violet, which is entirely invisible to the eye, has its maximum sensitiveness in the violet, to which

the eye is comparatively insensitive, is only slightly sensitive to the green, and is totally insensitive to yellow and red.[1]

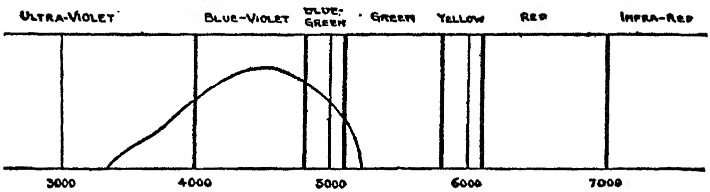


FIG. 32

Orthochromatic Film.—It is possible, by adding certain dyes to the emulsion, either at the time of manufacture or by bathing the film afterward, to

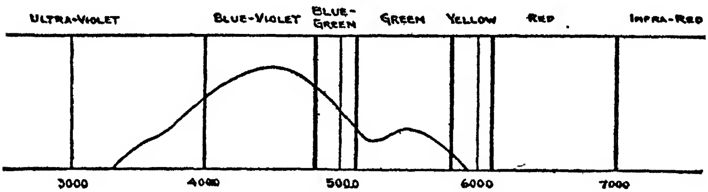
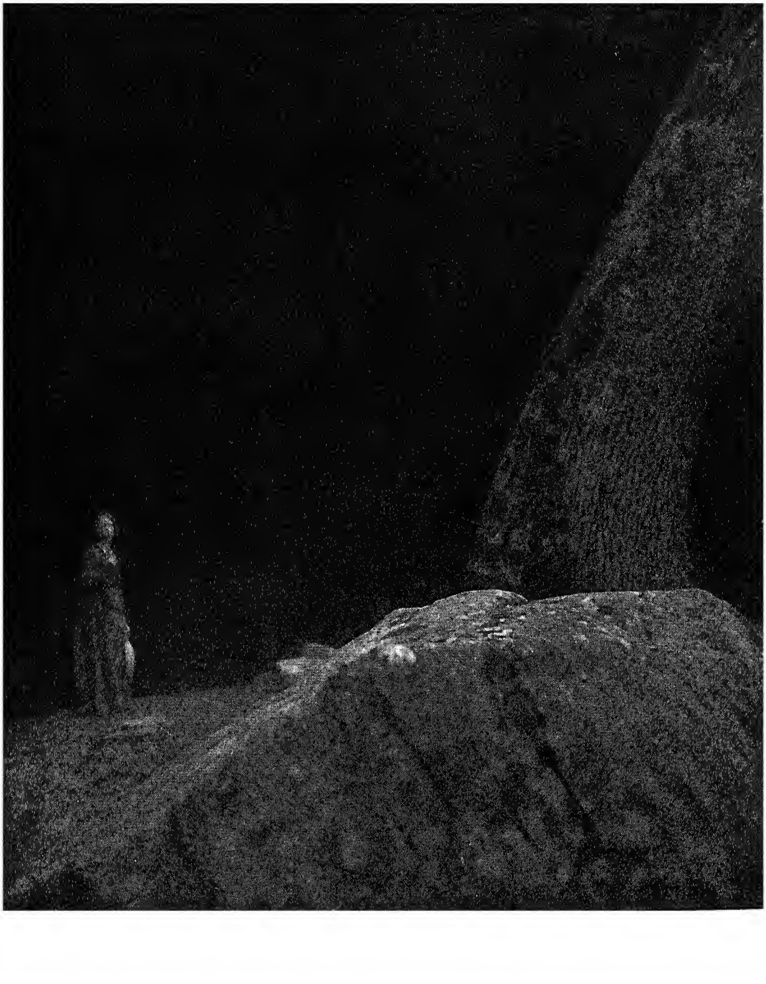


FIG. 33

extend the sensitiveness somewhat, producing what is known as an orthochromatic ("right-colored") or isochromatic ("equally colored") film, and the color-sensitiveness curve of such a film is shown in Figure 33. It will be seen that this film is sensitive to green and yellow in addition to the ultra-violet,

[1] A yellow or red object may, it is true, be photographed, by reason of the fact that a small percentage of white light is reflected unchanged from the surface of the object, but, though red or yellow is not rendered as absolutely black, as would be the case if a pure spectrum were photographed, it will still be reproduced as much too dark.



THE CAVE
BY CLARENCE H. WHITE
From a Platinum Print

violet, and blue-green, but still remains insensitive to red, and is but slightly sensitive to yellow, while retaining the ultra-violet sensitiveness. The terms orthochromatic and isochromatic are therefore not strictly correct, but they are generally accepted.

Panchromatic Film.—Certain other dyes, if added to the emulsion, render it sensitive to all visible light, and such films are called panchromatic ("all-colored"), trichromatic ("three-colored") or spectrum films; the approximate color-sensitiveness curve of such emulsions is shown in Figure 34, though

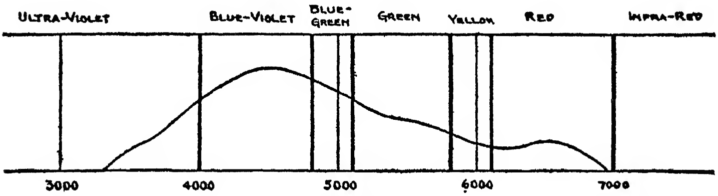


FIG. 34

panchromatic emulsions vary considerably, the color-sensitiveness of some extending into the infra-red. It will be seen from these diagrams that all emulsions, whether ordinary, orthochromatic, or panchromatic, are excessively sensitive to violet, which is dark to the eye, and to ultra-violet, which is totally invisible, and in order to correct this faulty sensitiveness it is necessary to employ a device known as a ray-filter or ray-screen, but before discussing the filter we will first consider the effect of photographing without it.

Color-Sensitiveness Percentages.—In "Orthochromatic Filters" Dr. C. E. K. Mees gives the following table of the sensitiveness percentages of different types of emulsion:

Type of Emulsion	Ultra-Violet and Violet Sensitiveness	Color Sensitiveness (Green, Yellow and Red)
Orthochromatic....	95 to 98 per cent.	2 to 5 per cent.
Panchromatic......	82 per cent.	18 per cent.

To these we may add

Ordinary..........	100 per cent.	0 per cent.

for, although yellow and red will register on an ordinary film if sufficient exposure be given, so long a time will be required that the other colors will be tremendously over-exposed.

The test chart given in Figure 35 shows the effect of photographing colored objects on ordinary, orthochromatic, and panchromatic films, both without and with a fully correcting filter. This chart is that given in Dr. Mees' book, The Photography of Colored Objects, and the photographs were made by the present writer. It will be seen that the panchromatic emulsion with the filter gave the most satisfactory rendering of the relative brightness of the various colors, and it should be borne in mind that this test is more favorable to the ordinary and orthochromatic emulsions than a photograph of a pure spectrum would be, since all the colors of the chart reflect some white light, and the conditions are therefore more nearly those of actual practice.

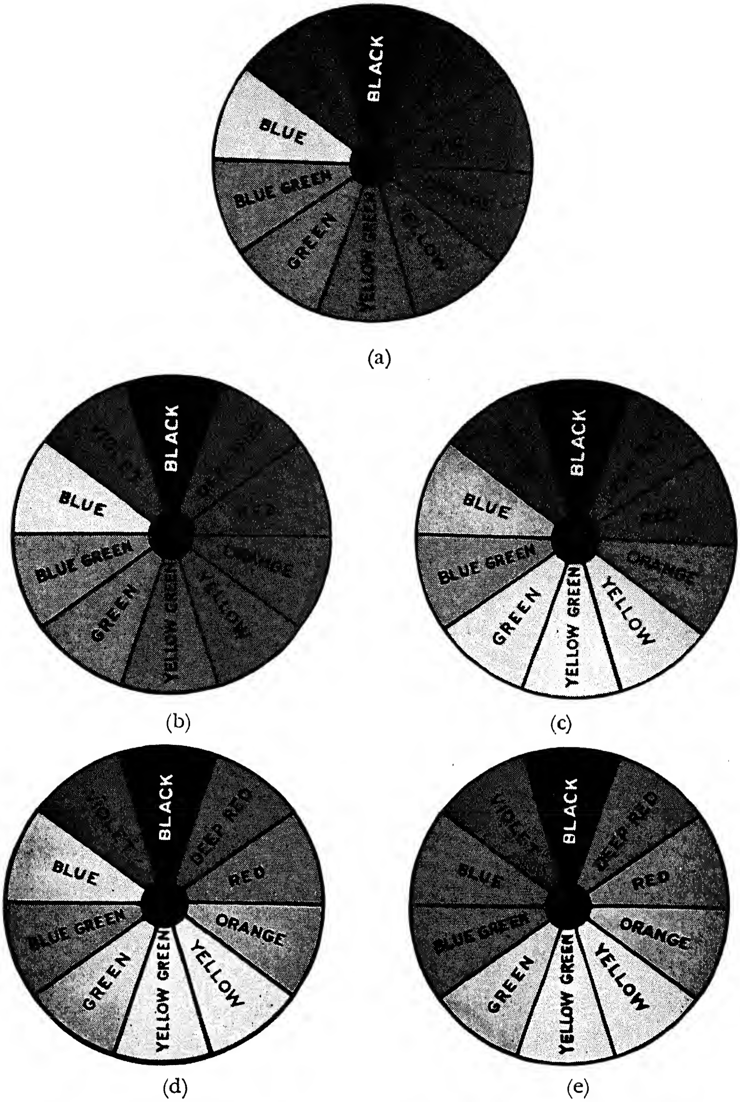


FIG. 35.—COLOR CHART PHOTOGRAPHED WITH VARIOUS EMULSION AND FILTER COMBINATIONS.

(a) ORDINARY (BLUE SENSITIVE) EMULSION.

(b) ORTHOCHROMATIC EMULSION, NO FILTER.

(c) ORTHOCHROMATIC EMULSION, FULLY CORRECTING FILTER.

(d) PANCHROMATIC EMULSION, NO FILTER.

(e) PANCHROMATIC EMULSION, FULLY CORRECTING FILTER.

PHOTOGRAPHING WITHOUT A RAY-FILTER.—When white light, that is, light containing all wave lengths, such as ordinary sunlight, falls on any natural object a portion is reflected unchanged from the surface, part is absorbed and quenched, and the remainder penetrates a short distance below the surface and is then reflected, the last portion being that which gives the object its color. It will be apparent that when this part is of a wave length to which the film is insensitive, the object is photographed entirely by that portion of the superficially reflected white light to which the film is sensitive, and, the violet sensitiveness of the emulsion being so far in excess of the color sensitiveness, this is what practically always occurs unless a filter is used.[2] The practical results of this fact will be considered so far as landscape and portraiture are concerned, since if the fundamental principles are grasped they may be applied to architecture, genre, and other forms of work, by anyone.

In landscape, assuming a sunny day, we find the sky to be a very intense blue, sunlit foliage a yellow-green, and foliage in shadow to be a blue-green, the last-named being illuminated entirely by reflected light from the sky. Hence we may expect the sky to photograph as very much lighter than it should, and, in fact, its actinic value is so nearly that of white that light clouds will be entirely lost, so far as printing

[2] Early in the morning and late in the afternoon the sun's rays pass through a stratum of relatively dense air carrying a higher percentage of moisture than that through which they pass near the middle of the day, and this air may act to some extent as a ray-filter.

value is concerned, though they may sometimes be distinguished in the negative. Foliage in shadow will photograph about as it should, the blue component of its illumination balancing to a great extent its local color, but foliage in sunlight will be darker than should be the case. Hence the foreground will be flat and lacking in contrast, the sky will be far too light, and clouds will not be retained unless they are very heavy, even heavy clouds being incorrectly rendered. In addition, ultra-violet light is markedly scattered by dust particles, smoke, and traces of mist in the air, so that the middle distance and the distance will be too light in value. If, however, a suitable ray-filter is used and exposure and development are approximately correct, the values throughout will be rendered exactly as they appear to the eye, and it may be noted that since there is seldom any great amount of red in a landscape an orthochromatic film is, generally speaking, as good as a panchromatic for this purpose, though if the ray-filter is to be omitted a panchromatic film should be used, on account of its greater color sensitiveness.

In portraiture, however, the case is somewhat different, and here the panchromatic emulsion is invariably superior to any other, for, though for pictorial reasons falsification of values is sometimes desirable in landscape, correct rendering is practically always desirable in portraiture. It is of course obvious that when it is said that the panchromatic film is invariably superior to any other it is assumed that the

photograph is to be made by white light or by some illumination containing a suitable proportion of yellow and red, for, naturally, if the mercury vapor arc is employed, a color-sensitive film presents no advantages over an ordinary one, the light in question containing no rays except ultra-violet and violet. However, it is assumed that the reader knows better than to expect a correct rendering of colored objects by monochromatic light, since it makes no difference whether the film is color blind or the object reflects no colored light. The skin of a healthy Caucasian is distinctly yellow, with an element of red in lips and cheeks, hair usually tends to warm brown, though in some individuals it may be yellow or red, eyes are usually of a bluish-gray, though sometimes brown, and skin blemishes are yellow or reddish. Wrinkles have a reddish tendency, due to small capillaries lying near the surface, and the faint lines under the eyes are purplish in hue. Hence we may expect an ordinary or orthochromatic emulsion to render the skin, hair, lips, skin blemishes, wrinkles, and lines under the eyes as too dark, and the eyes themselves as either too light or too dark. In addition, since the shadows of the face are usually of a different color than the lights, being illuminated by reflected light, it follows that the planes will be falsified, and this faulty rendering of planes may completely change the expression of the face. A comparison of the rendering of the ordinary and the panchromatic films is given in Figure 36, which was made in an ordinary

studio, A having been made on an ordinary film, and B on a panchromatic emulsion. No retouching or modifying of any sort has been done on either of these negatives or prints, and attention should be called to the fact that B is an exact rendering of the sitter's appearance. No ordinary or even orthochromatic film can render correctly a subject containing so much yellow and red as the face, even with a ray-filter, and if true values are to be obtained in portraiture a panchromatic film and filter are absolutely necessary. It is proof of the remarkable complaisance and equally remarkable lack of observation on the part of the public that portraits made on non-color-sensitive plates have been and still are being accepted by the sitters.

THE RAY-FILTER.—From what has been said it is apparent that in photographing on an ordinary or orthochromatic film we are photographing practically altogether by ultra-violet and violet light, and even if a panchromatic emulsion be used this is still to some extent the case, so that it is only in exceptional circumstances that the values can be rendered as they appear to the eye. If, however, some means be employed to subdue the excessive effect of the ultra-violet and violet rays, as well as a portion of the green, thus allowing the yellow and red opportunity to act on the emulsion before the effect of the other rays has become excessive, we can obtain correct values. Such a means is the ray-filter, which consists of a sheet of suitably dyed gelatine cemented

FIG. 36A.—TAKEN ON ORDINARY FILM

FIG. 36B.—TAKEN ON PANCHROMATIC FILM WITH FULLY CORRECTING FILTER

between two pieces of glass and arranged so that it may be interposed between the film and the object photographed, usually either immediately in front of the lens or immediately behind it. Filters are of two sorts, corrective and selective; the former having its absorption of light so adjusted that the sensitiveness curve of the film when used with the filter corresponds to that of the eye (except, of course, that the orthochromatic film has no red sensitiveness), whereas selective filters are so adjusted as to pass only a certain portion of the rays, thus emphasizing one region of the spectrum at the expense of the remainder. For instance, a red filter such as is used in three-color work transmits only red rays, absorbing the ultra-violet, violet, green, and part (the green component) of the yellow. Hence, if objects be photographed through such a filter any red portions will appear bright, since the light from these acts on the emulsion, all other colors seeming excessively dark. Selective filters are of value, generally speaking, only to process, commercial, and scientific workers, so will not be discussed here, readers who are interested being referred to the publications of the Eastman Kodak Company on this subject.

There are many different makes of filter on the market, some of them valuable and others worse than useless, for it is quite possible to over-correct a filter, that is, to give it an excessive absorption in one region of the spectrum, say the violet and green, so that yellow and red, when photographed through

the filter, will appear too light as compared to the other colors. Furthermore, since not all makes of film of one type have the same color-sensitiveness (not being sensitized with the same dyes) and since a panchromatic film may require an entirely different absorption from an orthochromatic, it is strongly recommended that the worker either obtain his ray-filter from the manufacturers of the film with which it is to be used or else make careful tests on a color chart. Attention should be drawn to the fact that even the use of a panchromatic film and an adjusted filter will not necessarily insure correct color rendering, since incorrect exposure will result in rendering some colors as too dark or too light, though there is considerable latitude in this respect, owing to the accommodation of the eye.

Also, it should be noted that since the light from Mazda and Photoflood lamps contains a relatively high percentage of red rays, the multiplying factor of a fully correcting filter will in general be somewhat less with such lights than with sunlight. And further, in some cases it is possible, by using a highly red-sensitive emulsion in conjunction with Mazda or Photoflood lamps, to get practically a true rendering of colored objects without using any filter whatever.

Some persons object to the use of a ray-filter on the ground that it prolongs exposure unduly, but this is not the case. Of course, it necessitates somewhat longer exposures, since some of the light which

would otherwise act on the film is absorbed by the filter, but filters may be obtained which give partial correction, with a decided improvement in color rendering, and require only a slight increase over the exposure necessary for the unscreened plate, while filters are to be had which give full correction and call for a multiplying factor of only from two to five, this being a great improvement on the old ones, with some of which the factor was as high as eighteen, that is, the exposure with the filter was eighteen times that without. It may be said that if a filter requires more than five times the exposure which would be necessary without it, that filter is either over-corrected or is inefficient, though this must be understood as applying only to corrective filters; selective filters often necessarily require more increase of exposure than this, as will be realized after brief reflection. That a factor of five does not necessitate unduly long exposures may be judged from the fact that the writer has made fully exposed negatives in a moderately well-lighted room at 11.00 A. M. in May with an exposure of 1/25 second, using a lens working at F/4.5 and a fast panchromatic film. Had the filter been used this would have meant an exposure of 1/5 second, which is quite within reason for practically all purposes. So far as landscape is concerned, the writer has never had to discard the filter on account of time of exposure except when working by moonlight. Practically all the writer's negatives are made with a fully correcting filter,

the screen being discarded only when falsification of values is desired, such as exaggeration of atmospheric perspective; or when photographing children indoors with poor light conditions. The matter of exaggeration of atmospheric perspective may require some further elucidation, and it will be remembered that mention has been made of the fact that ultra-violet light is strongly scattered by suspended particles in the air. It is well known that on a misty day the distance appears much higher in value than when the air is clear, this being due to the fact that the particles of water vapor, dust, and smoke reflect light back to the eye, without permitting it to reach the objects included in the landscape, thus giving the appearance of a veil drawn over the distance. This effect is observable in a lesser degree at all times, and furnishes one of the means whereby we estimate distance, whence the term atmospheric perspective. Ultra-violet light is scattered more strongly than the rays included in the visible portion of the spectrum, and, since ultra-violet light affects the film more strongly than the rays of a greater wave length, it follows that when any haze is present in the air the distance will appear lighter to the film than to the eye. If a suitable ray-filter is used, however, the effect on the film will be identical with the visual effect. Still, judgment must be used, as a single instance from the writer's experience will show. A photograph was made of a winding path in a park, a figure being posed in the middle distance, and

practically no sky being included in the view. The path was of a bluish-gray gravel, and was bordered by green lawns, the light values of gravel and grass being nearly the same, though by reason of the difference in color the path was clearly visible to the eye. Had a filter been employed, it would have been almost impossible to distinguish the path from the lawn in the negative, but the filter was omitted, and the path photographed much lighter than the grass. The values in the print were of course untrue to nature, but the pictorial result was good.

THE POLA SCREEN.—Pictorial workers in landscape not infrequently wish to darken the sky relatively to the foreground and middle distance, and to exaggerate somewhat any existing clouds. This can be done by the use of an over-correcting filter—that is, one which absorbs an excessive proportion of the violet and ultra-violet—but such a filter not only darkens the sky but in addition falsifies the values throughout the landscape. The desired effect may, however, often be secured without falsification of values, by means of an instrument known as the Pola Screen.

It has been explained that light vibrates in all planes with reference to its axis of transmission, but certain substances, such as tourmaline, possess the characteristic of allowing only that portion of the light which vibrates in one certain plane to pass through them. Light which is thus reduced to one single plane of vibration is said to be polarized. It

follows that two such plates, set at right angles to each other, are entirely opaque, though either one alone is transparent.

But light which is reflected at a certain angle from any natural surface is also more or less polarized, so it follows that reflected light may in certain circumstances be more or less quenched by a polarizing screen. A tourmaline screen of a size to be useful in photography would be prohibitive in cost, but polarizing screens have been artificially produced at a reasonable price, and such a screen may often be used to subdue the excessive brilliance of the sky without disturbing the color corrections of the rest of the scene.

However, the usefulness of such screens in pictorial work is limited, and the photographic artist will generally employ other means to secure the desired effect, though the commercial worker finds them of great value in subduing undesired reflections from polished surfaces, thus allowing a better rendering of the texture of the subject.

Choice of a Film.—The writer strongly recommends that the worker select one plate or film and adhere to it throughout, and he advises a fast panchromatic emulsion, since this will do all that any other will, and a great deal that no other will accomplish, this advice being, of course, based on the supposition that the photographer intends to do various kinds of work. As explained above, if landscape work only is to be done, an orthochromatic

emulsion is practically as good as the panchromatic. It is true that a panchromatic film, being sensitive to all visible light, cannot conveniently be developed by inspection, but this fact involves no hardship to one who employs tank development, which is recommended in any case. Those workers who regard development as a form of recreation will object to the use of the tank, and as a consequence debar themselves from enjoying the advantages of panchromatic films; but those who, like the writer, consider the negative merely as a means to an end, are free to use fully color-sensitive emulsions, and will find that they present many advantages over others, not least among them being the elimination of retouching, since freckles and wrinkles are not exaggerated, and the values—and consequently the planes—are rendered precisely as they appear to the eye.

Halation.—It will in practically all cases be found advantageous to use a plate or film which is halation-proof, such a one being almost imperative in landscape work, so we will next consider the question of halation and the various methods of preventing it. It has already been stated that when a ray of light passes from one medium to another of different refractive index there is some reflection from the surface where the two mediums join, and it is this fact which is responsible for halation, as will be understood on referring to Figure 37, which represents a sectional view of a dry plate with a ray of light incident on it from the lens. If the light is

allowed to act for a sufficiently long time the chemical inertia of the emulsion is completely overcome and the light passes through it to the glass, part of it being reflected back in the manner shown, to a path some distance from its original path through

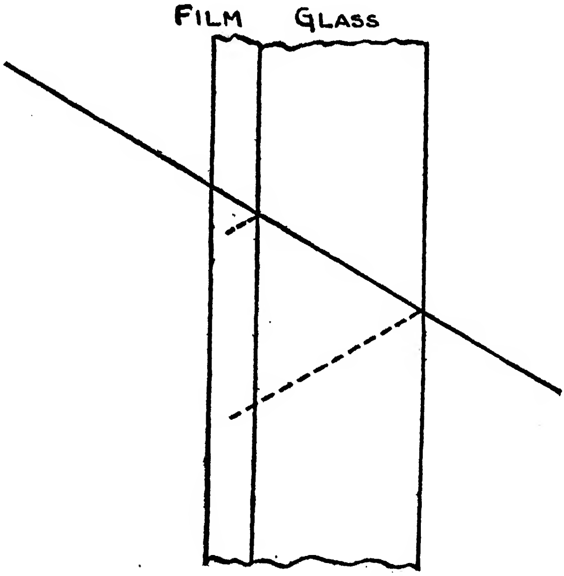


FIG. 37

the film, where it produces a secondary effect on the emulsion. This manifestation is apparent whenever a plate or film not especially prepared is used to photograph a subject having strong contrasts, such as a landscape with sky, an interior with windows, or a white dress against a dark background, and it shows itself both in the form of a halo spreading

from the light spaces into the dark ones and as excessive density in the lights of the picture. It may be avoided to some extent by special methods of development or be corrected by after-treatment of the negative, but the simplest means is to use a non-halation plate or film. There are several ways of preparing these.

(1) Double coating, that is, placing a slow emulsion on the glass and a fast one on that, so that the shadows will be recorded on the fast emulsion before the lights have had time to overcome the inertia of the slow one. This is the method used in the Standard Orthonon, Seed's L. Ortho Non-Halation, Eastman D. C. Ortho, and Hammer D. C. Ortho plates. (2) Using the same emulsion throughout but making it very thick, so that it has great inertia to the lights but little to the shadows. The writer does not know of any manufacturer now using this method. (3) Backing: that is, placing an opaque or non-actinic coating of about the same refractive index as glass or celluloid in optical contact with the back of the support, so that any light which reaches this surface is absorbed by the backing. When used with plates, the backing is generally a mixture of mucilage and lamp-black, which must be swabbed off after fixing, and is exceedingly messy. This method is out of use so far as plates are concerned, but many film manufacturers incorporate a non-actinic dye with the gelatine backing which is placed on films to prevent curling, this dye being either dis-

charged or decolorized in the process of developing and fixing. This method is very effective and convenient, and gives no trouble except as will be noted later when discussing intensification and reduction. (4) A variant of (3) which is equally good or perhaps even a trifle better is to place the non-actinic dye in a substratum of gelatine between the emulsion and the support. Some film manufacturers use this in preference to (3). (5) If the emulsion is coated on a very thin support, the reflected light returns to the emulsion so near its original path that it is only slightly apparent as a halo. The over-exposure of the lights still exists, however. (6) If hydrazine is incorporated with the emulsion, over-exposure, and consequently halation, becomes almost impossible. A plate so treated was at one time on the market, but presented other failings which caused it to be withdrawn. (7) An exceedingly efficient method of preventing halation, which has not been used for many years, and which is noted here simply as a matter of historical interest, was that used by the makers of the Cristoid film. In this case a double emulsion, as described in (1), was coated on glass and was then stripped off, only the sensitized gelatine being sold. This film had a long scale of gradation, and was beautifully halation-proof, but it was difficult to handle in processing on account of the consistency to which wetting reduced the gelatine. One very interesting characteristic of this film was that it expanded about 20% in processing, so that if one

started with an 8×10 film and dried it on a ferrotype plate or a sheet of glass, the final negative was about 10×12 inches. (8) Practically every 35-mm. film now on the market is made non-halation by incorporating a light tint (either blue or gray) in the celluloid support. Such film is ordinarily known in the trade as "gray-back."

Bromide Paper.—It is quite possible to use bromide paper instead of plates for making negatives direct in the camera, the advantages being lightness, freedom from danger of breakage, compactness in storing, freedom from halation, ease of modifying the negatives with pencil or stump, and the fact that the grain of the paper imparts an interesting texture to the print. The disadvantages are that bromide paper is obtainable only in color-blind emulsions, that it requires slightly longer to print, and that the speed is from 1/20 to 1/100 that of the average film. It is apparent that the worker who desires to use this method should choose a fast emulsion, coated on a thin, smooth stock, and it is further to be observed that if the negatives are smaller than 6½×8½ the grain of the paper is likely to become unpleasantly apparent. Nevertheless, within these limitations paper negatives are capable of giving good results, as is shown by the fact that all of D. O. Hill's magnificent portraits were printed from such negatives, and by the fact that many of the best workers use bromide paper exclusively for enlarged negatives, this fact being considered further in Chapter VII.

Plates or Films.—When this book was first written, the plates available were so far superior, in both working characteristics and reliability, to the films, that practically every serious worker used the former. But during the years that have elapsed since that time, so much research work has been done by the manufacturers that to-day one may obtain films of practically any speed or degree of color sensitiveness, and of a perfectly satisfactory reliability. As a result, almost all pictorial negatives are now made on films, plates being used chiefly for special purposes, such as commercial and scientific work. Films possess a great advantage over plates in the matter of portability, and the question therefore resolves itself into a choice between roll film and cut film, this being decided almost entirely by the type of camera which the worker prefers, there being little or no choice so far as results are concerned. The writer uses both roll and cut films in his own work, and finds no superiority in either type.

CHAPTER IV

Exposure and Development

Characteristic Curve of Plate.—If successive portions of a dry plate or film be given progressively increasing exposures to a standard illumination, and the plate or film be developed in any standard developer, the densities of the different portions being measured (after fixing, washing, and drying) by means of a densitometer, a curve may be plotted in which abscissæ represent light-action[1] and ordinates densities, and it will be found that the form of this curve is constant for every make and type of emulsion, though the actual dimensions may vary. This curve is known as the characteristic curve of the plate, and is due to the classical investigations of Messrs. Hurter and Driffield, two English scientists who made a series of experiments with regard to exposure and development, many years ago. This curve is shown in Figure 38, and it will be seen that it may be divided into four portions, (A) in which density increases relatively more rapidly than light-action, (B) in which density and light-action increase

[1] In scientific work, it is customary to plot the abscissæ as the logarithm of the exposure time, this being done merely in order to keep the dimensions of the curve within convenient limits. For the purpose of simplifying the explanation, this factor is here referred to as "light-action."

in the same ratio, (C) in which density increases relatively less rapidly than light-action, and (D) in which density decreases as light-action increases. The first corresponds to under-exposure, the second to normal exposure, the third to over-exposure, and the fourth to reversal, in which the plate develops as a positive

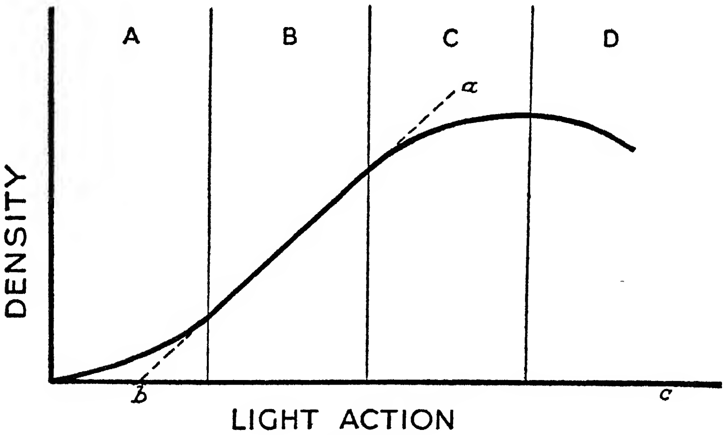


FIG. 38

instead of a negative, this last-named phenomenon being of laboratory interest only.

In order to make the meaning of this curve clear to the non-scientific reader, let us suppose that we wish to photograph three objects, and to reproduce them in their proper relative values, one of the objects being white, one black, and one of a gray which is midway between white and black. Obviously, the gray object should have, in the negative, such density that its image, in the print, will have a value

midway between that of the white and that of the black objects, and this will be the case if the exposure was what we call normal. If, however, the exposure was insufficient, the density of the gray object will be nearer that of the black than that of the white, all the values, of course, being incorrectly rendered. On the other hand, if the exposure was excessive the density of the gray object will be nearer that of the white than that of the black, the values being as faulty as in the other case, though in a dif-

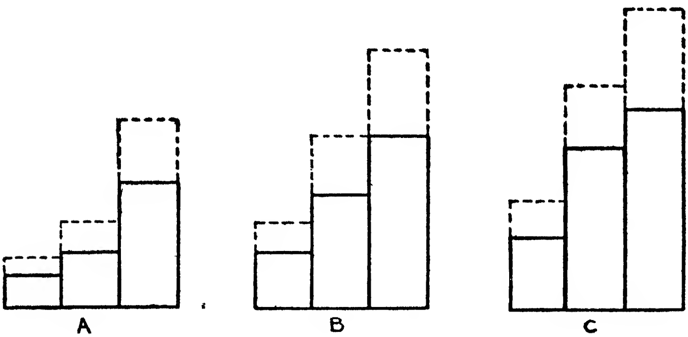


FIG. 39

ferent manner. This may be understood by reference to Figure 39, in which (A) represents under-exposure, (B) normal, and (C) over-exposure. These facts are usually expressed by saying that under-exposure flattens the shadows, giving a thin negative lacking in shadow detail, and that over-exposure flattens the lights, giving a thick negative which lacks brilliance. Messrs. Hurter and Driffield also found that this in-

ternal relationship of values cannot be altered by any modifications of development or by changes in the composition of the developer, thus disproving the popular idea that errors of exposure may be corrected in development. It is true that the contrast of the negative may be increased by prolonging development or decreased by giving shorter development than normal, but the internal relationship (except in one special case, which will be discussed later) is fixed once for all by the exposure. In Figure 39 the dotted lines represent the densities of the various gradations with prolonged development.

HURTER AND DRIFFIELD'S LAW.—These facts may be expressed in the form of a law, as follows:

Relative contrast is a function of exposure.

Actual contrast is a function of development.

The term "actual contrast" of course refers to the separation between the extremes of the negative. That is, to refer again to the illustration of the three objects, short development may result in rendering the black object as a dark gray and the white object as a light gray, whereas excessive development may result in extending the scale of the negative beyond the capacity of any printing paper to render; but the relation of white, gray and black is not changed by any variations in development.

TREATMENT OF UNDER- AND OVER-EXPOSURE.—For many years, photographers believed that it was possible to correct for errors of exposure by modifying the developer after development had begun. The re-

searches of Hurter and Driffield showed the falsity of this idea, and further, now that pictorial workers almost invariably develop by time and temperature, and usually in a tank, errors of exposure seldom are discovered until after the films are fixed.

If, however, either under- or over-exposure is known beforehand, prolonging development will help to prepare the negative for certain after-treatments which will tend to give a negative more nearly resembling a normal one than could be secured without such after-processing.

An under-exposed and normally developed negative is thin and lacks shadow detail, the scale of gradation being harsh, since the lights are relatively strong as compared with the lower tones. If development is prolonged, the negative will be excessively harsh, and the scale of gradation will very probably exceed that of any printing paper, but all possible shadow detail will be brought out. Then if this negative is reduced with ammonium persulfate, which attacks a dense deposit of silver much more than it does a thin one, the highlights will be reduced without reducing the shadows, the scale will be brought within a possible printing range, and the final result will be better than if normal development had been adhered to.

On the other hand, an over-exposed negative is characteristically dense, with flat highlights, but by forcing development up to but not beyond the fogging point, the highlights are given all possible vigor,

and subsequent reduction with Farmer's reducer, which attacks a thin deposit of silver in preference to a heavy one, will cut down the density to give a reasonable printing time, also tending, obviously, to increase the contrast, which is what an over-exposed negative needs. Then if further treatment seems necessary, the reduction having been carried as far as possible without losing shadow detail, intensification with the mercuric chloride formula given in Chapter VI may help, since this intensifier tends to add considerable strength to the lights and but little to the shadows.

From all this it follows that in order to get good values (i.e., a correct internal relationship of the gradations of the subject) the exposure must be such that the density range of the negative falls within the straight portion of the curve; that this requires more exposure than is necessary to get shadow detail; and that development should not be so great as to extend the range of gradations of the negative beyond the possible scale of the printing paper which is to be used.

Obviously, of course, either under- or over-exposure may be used deliberately, in conjunction with either normal, under-, or over-development, in order to obtain special pictorial effects; the artist not seldom falsifies his values deliberately, and a knowledge of the value of technically incorrect exposure and development is almost imperative to anyone who aspires to be more than a mere record worker.

FAILURE OF HURTER AND DRIFFIELD'S LAW.—There is one case in which this law fails; namely, in the case of relatively brief development in a very dilute solution. This exception to the law was noted by Messrs. Hurter and Driffield, and is explicable in the following manner: When a film is exposed on objects having a range of gradation from dark to light (as is always the case in pictorial work) the action of the light reflected from the lighter objects extends fairly deep into the emulsion, whereas the light-action in the shadows may be chiefly on or near the surface. When a developer is applied to the film the light-affected silver salt on the surface is readily reduced to the metallic state, but in order that the underlying portions may be developed it is necessary that the reducing agent penetrate deep into the gelatine. If the developer is very dilute a given volume of the solution carries but a small amount of reducing agent, and this readily becomes exhausted in acting on the silver salt. If the action is taking place near the surface of the emulsion the exhausted developer may easily be got out of the film and replaced by fresh, whereas if it is going on deep within the emulsion some time is required for the exhausted agent to be replaced, and all the while the reduction of the surface silver (that is, the shadows) is proceeding. Hence if development is arrested before all the light-affected silver salt has been reduced to the metallic state the shadows will have normal density but the lights will have less than

they should, and the negative will have somewhat the appearance of over-exposure, though the variation from normal will be very slight. Therefore, in the case of known under-exposure the use of a very dilute developer will tend to produce better results than normal treatment. Of course, if a strong developer is used this flattening of the lights does not take place, since the reducing agent is not so readily exhausted within the film.

It is apparent from this that tank development, that is, relatively long development in a weak developer, is more likely to produce a fully graded negative than shorter treatment in a strong developer, this being one of the arguments in favor of the time and temperature method of processing.

Characteristics of Abnormal Negatives.—The writer has found that many persons, even some who have had considerable photographic experience, are unable to determine by inspection whether a negative is under-exposed or under-developed as well as whether it is over-exposed or over-developed, and it seems advisable to indicate the difference in appearance of these faults. An under-exposed negative will, as stated above, be thin all over—assuming that development has been normal—will be lacking in shadow detail, and will show excessive contrast between the lights and the shadows. Under-development will give a film which will be thin, but will probably show some indications of shadow detail, and will have a normal range of gradation. Over-ex-

posure results in a dense, flat negative, lacking in brilliance in the lights, whereas a normally exposed but over-developed film, though dense all over, will have brilliance and contrast. Some little experience will be necessary before the worker can distinguish readily between these failings, and it would be very profitable for a young photographer to make a series of experiments in which under-, normal, and over-exposure are combined with under-, normal, and over-development.

GAMMA.—Of recent years, photographers have shown much interest in gamma—as the salesmen and advertisers express it in their quaint jargon, they have become gamma conscious—some film manufacturers even going so far as to include, in their instruction sheets, tables giving the development times for different gammas with the various recommended developers. Therefore a few words concerning this very interesting little gadget may not be out of place.

Referring again to the characteristic curve of the emulsion, it will be seen that if the straight portion of the curve be produced downward, as shown by the dotted line (Fig. 38) it will meet the horizontal axis at an angle abc, this angle depending on the steepness of the curve, which in turn depends on the characteristics of the emulsion, the contrasts in the original subject, the composition and temperature of the developer, and the time of development. Messrs. Hurter and Driffield gave the name of "γ" ("gamma," the third letter of the Greek alphabet) to

the tangent of this angle abc, and it will be obvious that γ is a measure of the contrast of the negative, since it increases with the steepness of the characteristic curve. It will also be obvious that although gamma is extremely useful to the research worker or to the laboratory technician, it has no value whatever for the pictorialist, since it cannot be translated into practice unless one knows both the contrasts of his subject and the characteristics of the printing medium that he intends to use.

Even if gamma can be translated into practice, the writer seriously doubts the wisdom of trying to do so, at least as far as pictorial work is concerned. The pictorial photographer is—or should be—an artist, but if he permits himself to become too deeply concerned with the scientific aspect of photography he inevitably loses sight of the artistic purpose which was his original aim; the writer has seen this happen in a number of cases. So on the whole it seems best for the pictorialist to forget about gamma, to rely on his judgment, and to correct any possible errors of development by means of the various simple processes of reduction and intensification, or by taking advantage of the tremendous possibilities of control which inhere in the various printing mediums. This discussion of gamma is included merely to clear up the considerable amount of confusion which seems to exist in the minds of those amateurs who would like to reduce art to a series of measurements "by rule and line," an attempt which is foredoomed

ST. MARY'S GRAVEYARD
BY A. K. ASTER
From a Palladium Print

to failure; it is not possible to render any form of artistic expression entirely automatic and fool-proof. "No one has ever yet invented a satisfactory substitute for brains."

Hypersensitizing.—In response to the demand for extremely brief exposures, the manufacturers of films have produced a number of ultra-fast emulsions, and Drs. Dersch and Luerr of the Agfa Ansco Company have devised a convenient method of hypersensitizing whereby the emulsion speed can be further increased.

By this method the film, either bare or in the roll, is placed in a sealed container with a small amount (10 grams or so) of metallic mercury, and is left exposed to the mercury vapor for the required time, which in the case of bare film will be about 36 hours, rolled film requiring a week. Care should be taken that the film does not come into contact with the mercury.

The speed of the film is thus increased from 50% to 150%, a markedly greater increase occurring if the film is treated after exposure rather than before. No change in grain size or in the working characteristics of the film is apparent. The effect of the hypersensitizing gradually fades over a period of about four weeks, but may be renewed by repeating the treatment. The effect of this treatment becomes more apparent as the exposure approaches normal; that is, it seems to be relatively more effective with slight, than with gross, under-exposure.

This method of increasing emulsion speed is not applicable to all films, some of the ultra-fast panchromatic emulsions fogging badly when so treated, but in many cases it works well, though it is inclined to be somewhat uncertain and treacherous.

Function and Composition of the Developer.—Although the action of the light is to effect a change in the sensitive salt contained in the film, no change is visible until the plate has been treated with a developer, unless, indeed, the exposure be tremendously excessive. The function of the developer is to reduce the light-affected salt to metallic silver, and the developing solution generally consists of water, a reducing agent, a preservative, to keep the reducing agent from being oxidized too rapidly by the oxygen in the water, and an alkali, the precise effect of this latter ingredient not being accurately known. Some reducing agents, notably amidol, do not require the addition of a specific alkali, but in general this ingredient is included. There are more than a hundred and fifty different substances which can be used for development, most of them derived from coal-tar, though some are obtained from nut-galls, lichens, sea-weed, or other vegetable substances, and one is inorganic. However, many of the reducing agents formerly on the market have disappeared in the course of years, the ones now chiefly in use being pyro (pyrogallic acid), various combinations of metol and hydroquinone, glycin, paraphenylene-diamine (principally used in fine-grain developers) and, for

bromide papers, adurol (chlorohydroquinone) and amidol. The preservative most in use is sodium sulfite, though potassium metabisulfite, and other chemicals, are sometimes employed. The most usual alkali is sodium carbonate, but caustic soda, caustic potash, carbonate of potash, borax, sodium metaborate, and other alkalis, are also used. Formulæ for different solutions will be given later, together with a brief discussion of the characteristics of the better-known reducing agents.

Methods of Development.—There are four methods of development, (a) by inspection, (b) factorial, (c) by time in a tray and (d) by time in a tank. In development by inspection the exposed film is taken from the holder in the dark-room, immersed in a tray of developer, and rocked until the worker judges, from looking at the negative by transmitted light (non-actinic light, of course), that development has progressed far enough to give the desired quality of print. This is the most laborious, most uncertain, and least scientific method, besides being most likely to result in damage to the negative from scratches or fog, no dark-room light being absolutely safe. In addition to the other reasons for discarding this form of development, we may note that if there is much work to be done a very noticeable reduction of the worker's vitality results from a prolonged stay in the dark-room. Some photographers profess to enjoy dark-room work, and when this is the case all that can be said is that if the worker regards de-

velopment as a form of amusement he should by all means develop by inspection; but those photographers who, like the writer, consider the negative merely as a means to an end—the print—will do well to adopt some other method.

The factorial method, worked out by Alfred Watkins, depends on the fact that for every reducing agent, irrespective of the concentration and composition of the developing solution, there is a definite ratio between the time required for the plate to gain all the contrast possible in the given circumstances, and the time required for the image to make its appearance after immersion in the developer. This ratio is known as the factor, and there are but few exceptions to the rule stated, pyro and amidol being the best-known of the agents whose factor depends on the strength of the solution. Mr. Watkins has determined the factors for many reducing agents, and gives the following table:

Adurol	5	Imogen sulphite	6
Amidol (2 grains per ounce)	18	Kachin	10
Azol	30	Mequin	12
Certinal	30	Metol	30
Diogen	12	Ortol	10
Edinol	20	Paraminophenol	16
Eikonogen	9	Pyrocatechin	10
Glycin-potash	12	Quinomet	30
Glycin-soda	8	Rodinal	30
Hydroquinone	5	Synthol	30

Pyro, no bromide.

Grains of Pyro per Ounce of Solution	Factor
1	18
2	12
3	10
4	8
5	6½

Azol, certinal, citol, and rodinal are said to be the same product under different trade names, being a concentrated solution of paraminophenol with preservative and caustic alkali. It may be noted that in numerous other cases different names represent the same chemical. Thus, mětol and elon are identical except that the former is put out by Hauff and the latter by the Eastman Kodak Company. To employ the factorial method of development the factor to be used in the specific case is first determined (using, of course, a smaller factor than the one given if less than maximum contrast is desired) and the film is immersed in the solution in the dark-room, the tray being rocked and the film watched until the image first begins to appear. The time required for this first appearance is multiplied by the factor chosen, and the film is developed for the total time thus indicated. Of course, the tray may be covered during development, thus minimizing the risk of fog. To take a concrete example, suppose rodinal is being used and a soft negative is desired. The factor chosen would probably be about 20, depending on the contrast in the subject and the quality of the result to be obtained. Suppose the image to appear in 10 seconds, then the total time of development would be 200 seconds, and the film would be developed for three minutes and twenty seconds from the first immersion, being fixed and washed at the expiration of the time, without the need for further examination. This method represents a great advance on the

inspection method, but is little used to-day, being described here partly as a matter of historical interest, and partly because the factors, as determined by Watkins, give a clue to the reason for the use of the most popular of present-day developers, the metol-hydroquinone combination.

It was observed that the long-factor developers, such as metol and rodinal, tend to act at first on the surface of the emulsion, bringing out all the gradations at an early period, and building up the strength of the deeper exposures rather slowly. Therefore such developers tend to give fully graded negatives of little contrast. On the other hand, the short-factor agents, such as hydroquinone and adurol, tend to work on the silver bromide in proportion to the light-action, building up contrast but—if the development is short—failing to bring out the shadow detail. But by a proper combination of two such agents, well-balanced negatives, fully graded, with good shadow detail and adequate contrast, are secured. Many such combinations have been tried, but the one which has proved most generally satisfactory is, as has been said, a mixture of metol and hydroquinone.

A certain characteristic of pyro, and of pyro derivatives, such as rubinol, should be noted. That is that such a developer tends to give a warm-colored image, of a reddish brown tint, and this, being markedly non-actinic, has much more printing vigor than a neutral-colored one which seems to the eye

to be of the same contrast. This characteristic rendered pyro a favorite with many professionals, who believed that it gave them "snappier" negatives than any other agent, though as a matter of fact the same degree of printing brilliance can be secured with a neutral-tinted image, simply by developing somewhat longer.

It has been found that this characteristic of pyro is not due to any difference in the silver image, but to the fact that the image consists partly of metallic silver and partly of stain; it is quite possible to remove the silver image from the negative and still retain a printable dye image. This circumstance is used to advantage in developing miniature films, where prolonged development, to get adequate contrast, results in excessive graininess; the inclusion of a certain amount of pyro or of rubinol in the developer makes it possible to shorten development for a given degree of contrast, thus minimizing grain but at the same time securing negatives which, by reason of the additional stain image, have a sufficient degree of brilliance.

In time development in a tray the film is immersed in the developing solution and the tray rocked for a predetermined length of time, this time depending on the composition, strength, and temperature of the solution (since all developers act more rapidly at high temperatures than at low ones) and on the development speed of the emulsion, different makes varying greatly in this respect. Only

experience can tell how long to develop in order to get the desired contrast, but this method is very convenient for those workers who are willing to make a few experiments with their customary brand of film, in the event of there being only one or two exposures to develop. Obviously, there is no need of using a dark-room light when time development is employed, so that this forms a very desirable method when traveling, since any room can be used as a dark-room at night.

Tank development is merely development by time and temperature, in circumstances so arranged that a number of exposures can be developed at once, in a vertical position. There are many developing tanks on the market, for either rolls or cut films, most of them being provided with light-tight covers and funnels, so that a dark-room is necessary only for loading the films into a tank, all subsequent operations being carried out in an ordinarily lighted room. This represents a great convenience to the amateur whose dark-room facilities are limited, since almost any closet will serve for loading the films into the tank, and a bathroom or kitchen may be used for the processing operations.

The writer has used most of the various tanks, and sees little choice among them, though it should be noted that a tank of bakelite or stainless steel is preferable to one of nickel-plated metal, and that no tank in which the film winds on a celluloid apron can be satisfactorily used for developing roll films at

high temperatures. In general, the roll film tank in which the film is threaded into a spirally grooved rack is the better type. Also, for cut films, one tank is convenient to use and economical of developer, but the rack has a tendency to cause markings on the films, a little way in from the edges, so that the full area of the films cannot be used. On the other hand, developing cut films in hangers in an open tank is less convenient, uses more developer, and requires a dark-room. Another cut film tank, which avoids the above-mentioned faults, cannot be inverted during development and has no convenient means of agitation. And still a third tank, though excellent in other respects, accommodates only six cut films at a time, and is not available in sizes larger than $3\frac{1}{4} \times 4\frac{1}{4}$. In brief, no absolutely ideal tank, for either roll or cut film, has been produced up to the time of writing; each has its advantages and disadvantages, and the final choice must be with the user.

In extremely damp weather it may be found difficult to thread a roll film into a spirally grooved rack, in which case drying the rack over a gas or electric stove *immediately* before inserting the film will help matters. Also, the threading operation will at all times be easier if about half an inch is first cut, with scissors, from the extreme end of the film, and the corners are slightly rounded off.

The technique which the writer has found most satisfactory for developing both roll and cut film in light-tight tanks is as follows.

Technique of Developing.—The tank is first filled with developer at the proper temperature (65° to 70°F.; 18° to 21°C.) and the light is turned out. The film is then placed in the rack, which is gently lowered into the developer, and the cover is placed on the tank, the light then being turned on. Lowering the films into the developer as described avoids the chance of air-bubbles adhering to the gelatine and causing blank spots in the finished negative, something which is likely to occur if the rack is placed in the empty tank and the developer is poured into the tank through the funnel opening in the top. If cut films are being developed in hangers in an open tank, they are lowered into the developer one at a time, any air-bubbles being dislodged by bouncing the hanger sharply two or three times on the edge of the tank.

The films are then agitated gently but continuously during the developing period, this being the best insurance against uneven or streaky development. It should be noted that agitation shortens the developing time, the difference between continuous and occasional agitation amounting sometimes to as much as 30% of the required time. Also, in any tank, continuous agitation helps to prevent marks from the rack, which sometimes result with only occasional agitation.

When development is complete, the developer is poured off, the films are given one quick rinse in water, the tank is filled with a 2½% solution of

chrome alum (chromium and potassium sulfate) and the films are agitated for one minute, being allowed five minutes in this solution. The chrome alum has two functions; first, being acid, it neutralizes the alkaline developer and acts as a stop bath to prevent further development, thus minimizing the chance of streaks and stains; and second, it hardens the gelatine greatly, so that the negatives are much less likely to be injured in subsequent handling. It has been found that a 2½% solution is more efficient as a hardener than either a stronger or a weaker solution, and that five minutes in this produces the maximum effect. A convenient way to handle the chrome alum is to make up a nearly saturated solution, dissolving 1 pound (500 grams) of either powdered or granular chrome alum (the crystal form dissolves very slowly) in 50 ounces (1500 cc.) of warm water, and adding water enough to bring the total volume to 70 ounces (2500 cc.). Two and a quarter ounces (65 cc.) of this solution, made up to a total volume of sixteen ounces (500 cc.) with water, gives very nearly a 2½% solution. The stock solution keeps indefinitely before use, and the dilute solution may be used for several successive tanks of films, but it should not be kept over night, and in any case should be thrown away if its color changes from purple to a yellowish green. Some workers add sodium bisulfite or potassium metabisulfite to the dilute solution, to increase its acidity, but this is not in general necessary; the chrome alum is amply acid to

act as a stop bath. Some such addition may, however, be desirable in the special case discussed below.

After hardening, the chrome alum is poured off and the films are given one quick rinse with water, the tank then being filled with the fixing solution. As a rule, the writer prefers to fix in a freshly mixed 1 to 4 solution of plain hypo, since there is never any doubt as to the activity of such a fixing bath, whereas an acid hypo that is used repeatedly may be partly exhausted and fail to fix the negatives completely. The films should be fixed for twice as long as it takes the white silver salt to disappear, after which they are washed for an hour in running water or in twelve changes of five minutes each. If they are washed in running water, it is not sufficient to let the water run into the top of the tank at one side and out at the other; a hose or some other device should be used, so that the water is carried to the bottom of the tank and overflows at the top. A better arrangement is to have the water enter the tank at the top and leave at the bottom, but this is not always convenient, and the method suggested works satisfactorily provided the flow of water is moderately vigorous. Too much emphasis cannot be laid on proper fixing and washing, since the permanence of the negatives depends on the thoroughness with which these operations are carried out.

After washing, the films should be swabbed on both sides with a tuft of cotton, rinsed once, and hung up to dry in a moderately cool, dry, dust-free

place. It is important to remove all surface water from the films on hanging them up, or the drops of adhering water will cause spots of different density in the negatives. It is commonly recommended to remove this excess water with a viscose sponge, but the writer does not find this at all satisfactory; small fragments of the sponge are likely to break off and remain on the negative. A much better plan is to wipe the films, front and back, with a *soft* automobile windshield wiper blade.

In the case of some makes of film, it will be found that the anti-halation dye used by the manufacturers is not water-soluble, but remains to a greater or lesser extent after the processing described above, and interferes materially with printing. With such films, the dye may be decolorized (though not necessarily discharged) by the use of sodium bisulfite or potassium metabisulfite. Half an ounce (15 grams) of this salt, added to sixteen ounces (500 cc.) of the chrome alum bath or the hypo bath, or dissolved in sixteen ounces (500 cc.) of water and used to bathe the film after fixing and before washing, will accomplish the purpose.

After use, the tank and rack should be thoroughly rinsed and allowed to dry spontaneously; they should never be wiped, or specks of lint or dust will be left on them, to cause transparent spots in subsequent negatives; and dust spots, though merely annoying in large negatives, assume the proportions of a major calamity in miniature films.

In processing miniature films it must be borne in mind that since enlargements of relatively considerable size will probably be made from them, the utmost care must be used to avoid mechanical defects of any kind, since it is practically impossible to spot or retouch a miniature negative satisfactorily. This means that all tanks, graduates, and other utensils must be scrupulously clean, the developer must be filtered through paper after mixing, air-bubbles must be avoided, and on no account must either the front or the back of the film be handled with the fingers at any time; all handling must be by the edges. Of course these precautions are highly advisable with any film, whatever its size, but with miniatures they are imperative.

Developers.—There are on the market a great many ready-prepared developers, put up either in liquid form or as powders requiring merely to be dissolved in water for use, and the developers packaged by the established manufacturers are so reliable in every way that it is quite unnecessary for the amateur photographer to make up his own, unless he wishes to do so either for the sake of economy or for experimental purposes. Therefore it seems superfluous to fill the pages of this book with a multiplicity of formulæ, and the pictorial worker who wishes to prepare his own developer is referred to the instruction sheets that are packed in every box of films, and to the Eastman Kodak Company's book,

"Elementary Photographic Chemistry," where many tested formulæ are given in detail.

One formula will, however, be given here, since this is a developer which the writer has used with great satisfaction for many years. This formula was worked out by the writer from a suggestion in an old textbook, and during 1917 and 1918 the developer was marketed by Karl Struss and the writer under the name of Kalogen; it is a highly concentrated single solution requiring only dilution with water for use, and in working characteristics closely resembles rodinal, being suitable for either films or papers, though the composition is entirely different from that of rodinal.

Water, distilled	32 ounces	1000.0 cc.
Claritol	384 grains	26.4 grams
Sodium sulfite CP anhydrous	2625 grains	180.0 grams
Hydroquinone	768 grains	53.0 grams
Potassium bromide	128 grains	9.0 grams

When the above are mixed, a thick white precipitate results. Add

Sodium hydroxide	512 grains	35.1 grams

and stir. When the sodium hydroxide is dissolved, the solution will be clear. Elon or metol may be used instead of claritol, in which case only 192 grains (13.5 grams) should be used. Put the solution into a bottle, full to the top and lightly stoppered, and allow to stand for 24 hours, then filter through paper and bottle in 2-ounce or 4-ounce brown glass bottles with

rubber stoppers. The stock solution keeps in good condition for months. This is not specifically a fine-grain developer, and is not offered as such, but if a fine-grain film is used, and enlargements are made on rough paper or if any means of diffusing the grain is employed, it is possible to go up to ten diameters or more with it. Further, it is convenient and economical, and gives negatives of nice quality.

For tank development of films, use

Stock..................	1 ounce	30 cc.
Water..................	40 ounces	1200 cc.

The development time for most films will be from 5 to 10 minutes at 65°F. (18°C.), depending on the contrast desired.

For bromide and gas-light papers, use

Stock.........	1 ounce	30 cc.
Water.........	10 to 15 ounces	300 to 450 cc.

With some films and papers there may be a slight tendency to fog, which can be controlled by the addition of a small amount of potassium bromide.

If the concentrated solution is allowed to stand in a cold place, there may be a precipitation of crystals; this does no harm, and the crystals may be redissolved by warming and shaking the bottle.

In his book, "Die Neue Foto Schule," Hans Windisch gives a formula for metol without alkali, a notion which seems, to photographers of the old school, utterly revolutionary, but which has been shown, through experiments by the writer and others, to

work satisfactorily. Slightly modified from Herr Windisch's formula, it follows:

Water...........................	16	ounces	500 cc.	
Metol (or Elon)..................	38½	grains	2.5	grams
Sodium sulfite c p anhydrous.....	385	grains	25.0	grams

Dissolve in the order given. Developing time, 9 to 15 minutes at 65°F. (18°C.) with continuous agitation. This is a very fine developer, giving excellent shadow detail, good gradation, freedom from fog, and ample brilliance for any purpose. Further, though not offered as a fine-grain developer, it gives finer grain than many of the so-called "fine-grain" developers that are now on the market. It has also been found to work well with papers, though in the above concentration its action as a paper developer is somewhat slow.

Since metol is normally slightly acid, and will not function as a developer except in an alkaline solution, this formula seems rather anomalous. The explanation doubtless lies in the fact that the commercial sodium sulfite (even the c p grade) contains from 1/5 to 1/3 of 1% of sodium carbonate as an impurity, and this is sufficient to overcome the acidity of the metol.

This solution keeps fairly well, and may be used repeatedly.

Fine Grain.—The need for care in processing miniature films has already been pointed out, but in addition it is necessary to use special developers

which minimize the granularity of the silver image. This granularity is not due to the silver grains themselves, since these are too small to be seen except under tremendous magnification, but to the fact that they tend to gather in clumps during development; it is this clumping which causes the appearance of grain. This tendency is due partly to the character of the emulsion, a slow or medium speed film generally (though not invariably) giving finer grain than a fast one; and partly to the character of the developer.

A great many "fine-grain" developers have been devised, though up to the time of writing it has not been possible to produce any which does not give a decrease in emulsion speed, i. e., require an increase of exposure as compared to non-fine-grain developers. With some of the prepared fine-grain developers it is necessary to give from two to five times normal exposure, but in this respect two of the best which have appeared thus far are Champlin No. 16 and the Eastman Kodak Company's DK-20, these formulæ showing an emulsion speed of about 65% normal—a loss which is too small to be of practical importance. Both these developers give excellent results as regards both fineness of grain and negative quality, and both keep well and may be used repeatedly, but the Champlin formula has the disadvantage of calling for acid-free chloro-hydroquinone, something which cannot be obtained unless manu-

factured for immediate use, since this chemical hydrolyzes and turns acid within about a week, in storage. However, it must be said that acid samples of chloro-hydroquinone appear to work about as well as the acid-free article, so this cannot be considered a serious disadvantage. Both of these developers avoid the use of paraphenylenediamine, which is a constituent of most fine-grain developers, but is inconvenient to use, stains badly if it touches anything about the darkroom, and is extremely toxic to many persons.

The publishers of Mr. Champlin's book do not permit the reprinting of his copyrighted formula, but the Eastman Kodak Company formula follows, being taken from "Photographic Chemicals and Solutions," by Crabtree and Matthews.

DK–20

Water (about 125° F.; 52° C.)	96	ounces	750.0 cc.
Elon (or metol)	290	grains	5.0 grams
Sodium sulfite anhydrous	13¼	ounces	100.0 grams
Kodalk	116	grains	2.0 grams
Potassium sulfocyanate (thiocyanate)	58	grains	1.0 gram
Potassium bromide	29	grains	0.5 gram
Cold water to make	128	ounces	1000.0 cc.

Time of development, 15 to 25 minutes at 65° F. (18° C.).

The desire for fine-grain negatives is often carried too far, many photographers exerting themselves to secure fineness of grain when this is of no practical value in their work. This passion for fine grain is carried to such an extent, and the gullibility of the public is so great, that the writer has even known of ordinary hypo being packaged and sold as "Fine-

Grain Hypo," which, of course, is simply a plain case of deliberate fraud.

In compounding any developer which is to be kept for any length of time, either before or after use, it is strongly advised to use distilled water and the c p grade of chemicals rather than the "Photographic," the "Photo Pure," or any inferior quality, and to use care and accuracy in weighing and measuring. The few cents of additional cost, and the slight extra effort, will be more than repaid by the better keeping qualities and the better working of the solution.

METOL POISONING.—It should be noted that some persons are definitely allergic to metol and to paraphenylenediamine, the latter being by far the more toxic of the two. These agents produce in such individuals a skin irritation which somewhat resembles ivy poisoning but is far more stubborn, and when this occurs it is necessary either to abandon the toxic substance in favor of some non-toxic developer such as rubinol or pyro, or to make a practice of wearing rubber gloves while at work. In extreme cases even rubber gloves will not prevent the trouble, the minute quantities of metol or paraphenylenediamine dust in the air of the darkroom being sufficient to maintain the disorder. The latter agent is so very toxic that rubber gloves are advised for everyone using it. The irritation, if it occurs, is best treated with an ichthyol ointment.

Recent experiments with orthophenylenediamine

seem to indicate that this possesses all the merits of the para-form, without its toxicity, and we may expect to see fine-grain formulæ based on this more desirable agent.

DESENSITIZING.—Those workers who insist on developing by inspection can process panchromatic films in this manner if the emulsion is first desensitized by bathing (in total darkness) for three minutes in a 1 to 10,000 solution of pinakryptol green, that is:

Water, distilled........	2	gallons	10 liters
Pinakryptol green......	12	grains	1 gram

This keeps well in the dark, and may be used repeatedly, gradually losing its desensitizing power with use. After desensitizing, the film can safely be developed one foot from a Wratten Series 3 safelight using a 25-watt bulb. This technique is not so generally satisfactory as tank development.

CHAPTER V

Miscellaneous Apparatus

Exposure Tables and Exposure Meters.—There are four types of device that are used to determine the correct exposure. (1) The exposure table, in which numerical values are assigned to various light intensities, subjects, and film speeds, these being correlated for the subject in hand. (2) The Wynne and Watkins type, in which a piece of sensitized paper is exposed to the light, the time required for it to darken to match a standard tint is noted, and the exposure is calculated from this. (3) The extinction type, in which a numbered step wedge (either movable or stationary) is interposed between the eye and the light, and the exposure is calculated from the highest readable number. (4) The photo-electric type, in which a self-generating light-sensitive cell, connected to a micro-ammeter, is exposed to the light, and the exposure is calculated from the meter reading.

These instruments range in price from seventy-five cents to twenty dollars or so, and the writer has not found that any one of them possesses the slightest advantage over any of the others except in cost; any of them will serve as an excellent guide on which

the photographer can base his judgment, nor will any of them do more than this. Of recent years, a great effort has been made by the manufacturers of photographic apparatus to render photography entirely automatic and foolproof, but all such attempts are foredoomed to failure. A friend of the writer is fond of saying that "men have invented a lot of things, but no one has ever yet invented a satisfactory substitute for brains," and the need for judgment is nowhere greater than in the matter of exposure. Therefore the writer would advise every would-be pictorial photographer to obtain some form of note-book in which to record the data of light intensity, subject, film speed, lens stop, and exposure for each of his films, and studiously to compare these data with the resulting negatives; this is the quickest and surest way to gain the experience which will enable him to dispense entirely with all exposure meters. That this knowledge can be acquired is proved by a recent experience of the writer, who in the course of a week made ninety-six exposures on a wide variety of subjects, ranging from white buildings in sunshine to fairly dark interiors. No exposure guide of any sort was used, but, except for two negatives where circumstances prevented giving enough time, all were satisfactorily exposed. This is no miracle; plenty of photographers could do equally well, and anyone of normal intelligence can acquire the skill necessary to do so. And it is well to

gain this skill, for no exposure meter can rival experience and judgment. It should be noted that practically all exposure meters and tables are calculated to give shadow detail. But an examination of the characteristic curve (page 92) shows that shadow detail is secured before the negative reaches the straight-line portion of the curve. And since the exposure must fall within this straight-line portion if good values and gradation are to be obtained, it is almost always well to give at least twice as much exposure as the meter indicates, and sometimes even more. The Wynne meter, however, tends to give very full—often excessive—exposures.

Shutters.—In the past there have been many types and makes of shutter on the market, but only two have attained such popularity as to be of consequence to the pictorialist of to-day. These are (1) the gear-controlled between-lens shutter; and (2) the focal-plane shutter, each having its own advantages and disadvantages.

(1) In this type, a series of blades like an iris diaphragm opens and closes under the impulse of a spring, the speed of their action being controlled by a train of gears. The advantages of this shutter are:

(a) It is more compact than the focal-plane type.
(b) It can in general, though not invariably, give slower automatic exposures.
(c) It can be held rigidly in the hand for much

longer exposures than the focal-plane shutter.

(d) There is less time-lag (that is, the interval between pressing the trigger and the operation of the shutter) than with some makes of focal-plane shutter.

(e) There is no distortion of moving objects.

(2) The advantages of the focal-plane shutter are:

(a) It can give much shorter exposures than the between-lens type.

(b) Its efficiency (light-passing power in relation to total time of exposure) is somewhat higher than that of the other.

(c) It can be adapted to larger lenses.

(d) The actual speeds are usually nearer to the marked speeds.

In the better makes of between-lens shutter, the range of speeds is usually from 1 second to 1/400 or 1/500 second, whereas in the focal-plane type the range is generally from 1/10 to 1/1000 or 1/1200. Attachments are made for some focal-plane shutters which permit longer automatic exposures.

Since the blades of a between-lens shutter occupy some time in opening and closing, it is obvious that the lens is not fully open during the entire time of operation, wherefore the efficiency is cut down. But this difficulty does not exist with the focal-plane type, in which the slit is fully open during its entire

time of travel. However, the efficiency of a focal-plane shutter is not 100% (as is often claimed) unless the slit is actually in contact with the emulsion, a condition which practically never exists. In general, it may be said that the efficiency of a good focal-plane shutter will be in the neighborhood of 80%, and of a good between-lens instrument around 65%. Of course, the efficiency of the between-lens shutter is higher at the slow speeds than at the fast ones.

Since a perceptible time is required for the slit of a focal-plane shutter to travel across the film, it is obvious that part of the subject is exposed before that portion which lies on the opposite edge of the film. The image on the film is exposed, so to speak, in sections, and if the subject is moving rapidly the part that is exposed last may have traveled a considerable distance from the position which it occupied when the first section was exposed. This often results in serious distortion of the image.

Time-lag is not properly attributable to the shutter, but is due to the fact that in most reflex cameras the mirror must be got out of the way before the shutter operates; therefore it is actually a fault of the reflex design rather than of the shutter. However, this lag may at times amount to 1/5 second or even more, a serious matter when photographing objects in motion.

Since the full travel time of the slit in a focal-plane shutter is at least four times the light-exposure time of any single section of the film (and it may,

at the higher speeds, rise to forty times) it follows that if the negative is not to show blurring due to camera motion, the instrument must be held rigid for at least four times the exposure time. About the limit of time that the average person can hold a camera rigid is 1/10 second (though the writer knows a trained rifle-shot who can hold for one-second exposures) and for such an exposure with a focal-plane shutter the camera must be held still for nearly ½ second. With the between-lens shutter no such condition exists; there 1/10 second is 1/10 second for both light-exposure and camera-holding.

As between the two types, the writer is inclined to prefer the between-lens shutter where exposures shorter than 1/250 second are not required; for faster speeds, the focal-plane is preferable, if not imperative.

It is worth noting that there is one miniature camera which uses an all-metal focal-plane shutter, and for tropical use this is far better than any fabric shutter.

Miscellaneous Apparatus.—At present, formulae are almost always given in both the English and the metric systems, and since the latter is vastly more convenient, the worker is advised to use scales and graduates marked in this system, though if desired, graduates may be obtained with markings in both systems. The choice is not so conspicuous between the Fahrenheit and the Centigrade thermometric systems, though the latter is slightly preferable.

Scales should be of the type in which the weight is determined by means of a rider on a graduated beam, rather than by loose weights. Graduates should be of the conical, rather than the cylindrical type, since the former are less likely to be knocked over in the dim light and restricted space of the average dark-room. Pyrex beakers are desirable if solutions are to be heated. Thermometers should be all-glass, should be so weighted and balanced as to float upright in a graduate of solution, and should have a blue or red alcohol column rather than a mercury one. Print tongs should be of stainless steel, not wood. Tanks for developing and fixing should be of stainless steel or of bakelite; next to these, hard rubber is probably best. Trays constitute rather a problem. If much work is being done, stainless steel trays are not only the most satisfactory but also the most economical. They are, however, expensive, and require a large initial investment, so if the volume of work is not great, porcelain-lined steel may be preferable. The chief trouble with the latter is their tendency to chip and crack, exposing the bare metal; when this happens, they should be discarded or relegated to washing service. Sometimes, though, they can be salvaged by a touch of asphaltum varnish. Probably the best trays for amateur use are hard rubber, since they are cheap, are highly resistant to chemicals, are easily kept clean, and with reasonable care in handling will last a long time.

The dark-room walls, shelves, and workbench

should be painted or enameled in white or light cream, since this makes it much easier to see in the necessarily dim light, and if the illumination is properly adjusted to the sensitive material in use there is no danger of fogging; the idea that the dark-room should be painted black is pure superstition. Two or three coats of clear Valspar over the paint or enamel make a good, durable finish for the work-bench; benzole or turpentine will soften it up, but it will resist most chemicals. Valenite is Valspar with the pigment ground into it, and is convenient, but the writer has not found it to stand up so well as the clear varnish.

PART II

NEGATIVE MODIFICATIONS

CHAPTER VI

Manipulation of Negatives

MANIPULATION OF THE NEGATIVE.—It sometimes happens that the worker, either through failure in judgment or through exceptional conditions, does not succeed in obtaining the precise quality of negative desired, in which case much may be done to improve matters by either intensification or reduction. Also it not infrequently occurs that the relative values in the negative are not such as to give the best pictorial effect, even though they may be a correct rendering of the gradations in the original subject. In this case local intensification or reduction may advantageously be employed or the values may be improved by working with a pencil on either the front or the back of the negative, if the surface has been prepared so as to take the pencil well.

INTENSIFICATION.—There are many different intensifiers available, some of them useful and others distinctly undesirable, so it may be well to indicate what the characteristics of an intensifier should be.

In the first place, it should be capable of absolute control; that is, it should give either slight or great intensification, as may be desired. Second, it should be capable of being made up in a solution which

will keep well both before and after using. Third, it should not cause stains when handled with ordinary care. Fourth, it should give a deposit approximating in color that of the negative, that is, a neutral black or a warm black, since if it gives either a yellow or a red color it will be difficult to judge by inspection the degree of intensification. Fifth, the intensification should be permanent. Similar requirements are also true of reducers.

There are three intensifiers and two reducers which are of general use to the pictorialist, several others being available for special purposes. The intensifiers are:

(1) Mercuric chloride
(2) Chromium
(3) Silver

The reducers:

(1) Farmer's
(2) Ammonium persulfate

Before using any of these, the negative should be entirely free from hypo and should have been well hardened by immersion in a 2½% solution of chrome alum; if this has been done between development and fixing, as described on page 111, the operation need not be repeated.

Intensification.—The mercuric chloride intensifier is made up as follows:

Water...............	16 ounces	500 cc.
Potassium bromide....	150 grains	10 grams
Mercuric chloride.....	150 grains	10 grams

This keeps well, and may be used repeatedly.

The negative, either dry or wet, is immersed in this solution until the image, as seen on the back, is completely bleached to a creamy white. It is then washed for half an hour in running water, and is blackened in one of the following:

(a) A 10% solution of sodium sulfite
(b) Any ordinary developer
(c) A 10% solution of ammonia

(b) gives somewhat stronger intensification than (a), and (c) still stronger, though (c) acts more slowly than either of the others. The negative is then thoroughly washed and dried. If desired, the operation may be repeated, though the gain in intensity is less than the first time.

To use the chromium intensifier, make up the following solution:

Water..................	16 ounces	500 cc.
Hydrochloric acid cp.....	¾ dram	3 cc.
Potassium bichromate.....	60 grains	4 grams

This keeps indefinitely before use, but should be thrown away after using.

The negative is bleached and washed as with the mercury intensifier, and is blackened in any ordinary developer which does not contain a large proportion of sodium sulfite. Any yellow stain which remains after washing may be removed by a 2%

solution of sodium bisulfite, followed by several changes of water. After blackening, the negative is washed and dried. This gives about the same intensification as the mercury and sulfite treatment.

To use the silver intensifier, make up the following stock solutions:

(a)	Water, distilled	16	ounces	500	cc.
	Silver nitrate	1	ounce	30	grams
(b)	Water	16	ounces	500	cc.
	Sodium sulfite anhydrous	1	ounce	30	grams
(c)	Water	16	ounces	500	cc.
	Hypo	1¾	ounces	52.5	grams
(d)	Water	48	ounces	1500	cc.
	Sodium sulfite anhydrous	¼	ounce	7.5	grams
	Metol (or elon)	175	grains	12	grams

These solutions keep well before use, though the silver nitrate must be kept in the dark or in a brown glass bottle.

Add 1 part of (b) to 1 part of (a), stirring well; a white precipitate is formed. Add 1 part of (c), stirring well; the precipitate will be dissolved. Then add 3 parts of (d), stir well, and immerse the negative. Intensification proceeds gradually, and may be stopped at any point. This intensifier does not keep for more than 30 minutes at 70° F. (21° C.) after mixing, so intensification should not be continued for more than 25 minutes. If enough strength has not been gained in that time, a fresh solution must be used. After intensifying, the negative is fixed for three minutes in a 30% solution of hypo, then is washed and dried. The operation may be repeated if desired.

Reduction.—There is no single chemical which acts as a proportional reducer. Farmer's reducer acts more on the thin portions of the negative than on the dense ones, wherefore it tends to increase contrast, and is recommended for over-exposed negatives. Ammonium persulfate, on the other hand, acts more on the dense than on the thin parts, so is advised for over-developed negatives.

To use Farmer's reducer, make up the following solution:

Water................	16 ounces	500 cc.
Hypo.................	½ ounce	15 grams
Potassium ferricyanide..	7½ grains	0.5 gram

Note that potassium ferr*i*cyanide, not ferr*o*cyanide, is used. This reducer does not keep, and must be thrown away after use; if it changes color from a bright yellow to a pale green during use it must be thrown away and a fresh solution taken. The negative is immersed in this until sufficiently reduced, when it is thoroughly washed and dried.

To reduce with ammonium persulfate, make up the following stock solution:

Water..................	16 ounces	500 cc.
Ammonium persulfate....	1 ounce	30 grams
Sulfuric acid cp.........	25 drops	1.5 cc.

For use, take 1 part of the stock solution and 2 parts of water; immerse the negative, and when it is sufficiently reduced, fix it for a few minutes in an acid fixing bath, then wash and dry. In this solution, the reducing action starts slowly, then after starting, it proceeds rapidly, so the negative must be carefully

watched. Absolutely pure ammonium persulfate will not reduce, the action being due to a minute proportion of iron, which acts as a catalyst. The writer knows of only one manufacturer, the Eastman Kodak Company, that controls the percentage of iron in the persulfate; the products of other manufacturers may or may not work satisfactorily for this purpose.

An alternative method of selective reduction, sometimes preferred to the use of persulfate to correct excessive contrast, is to bleach in the chromium intensifier, wash, and redevelop in a very dilute (about 1/20 normal strength) developer. In this solution blackening proceeds very slowly, the thin parts blackening first, then the half-tones, and the dense parts last. When the desired strength is attained, the operation may be arrested and the undeveloped highlights dissolved out by an acid fixing bath. Thus the shadows and half-tones may be intensified, and the highlights reduced, thus cutting down contrast. This is a somewhat tricky method, the tendency being to arrest re-development too soon; it should be practiced with several worthless negatives before trying it on a valuable one.

In all reducing operations, and when intensifying with the silver formula, *constant* rocking of the tray is imperative.

Still another method of selective reduction, which does not endanger the negative, is to make a weak positive from the negative, by contact printing on a dry plate, and to bind this in register with the nega-

tive, printing or enlarging through the two. It is evident that by this method the result is very fully under control, by varying the exposure and development of the positive mask. It is imperative to use a plate for the mask, since a film will shrink and be impossible to register with the negative; a slow double-coated plate, such as the Standard Orthonon, the Seed's L Ortho Non-Halation, or the Eastman D. C. Ortho, is recommended, though others can very well be used.

Some film manufacturers use a non-halation dye which is decolorized but not discharged in the process of developing and fixing the negative, and which reappears during intensification or reduction in the form of a heavy dark stain which makes it difficult or even impossible to follow the operation in hand. In some cases this dye can be decolorized by a 2% or 3% solution of sodium bisulfite, but sometimes, especially with the silver intensifier, it is extremely stubborn. With such films it is advisable to use the positive mask method for reduction, and for intensification to build up contrast by making a strong positive by contact printing on a fairly hard-working film, and from this a negative of the desired quality.

Local reduction can sometimes be accomplished by applying Farmer's reducer with a soft brush or, preferably, a wad of cotton, and the silver intensifier can at times be used locally. In either case, the negative should be soaked in water for at least an hour before applying the chemicals. When using Farmer's

reducer locally, it should be used very weak—not over 1/5 normal strength.

Any of the methods described above can be used to improve bromide prints, Farmer's reducer being especially useful for brightening up prints which are dull from over-exposure. The intensifiers may be used as described, but the reducers should be diluted to 1/5 or 1/10 normal strength.

Retouching on the Film.—It is sometimes necessary to raise the value of small areas, as in touching out freckles in a portrait, and this is best done on the film when the lightening required is not great. Ordinarily a pencil will not take freely on the film unless this has been especially treated, though in the case of an intensified negative it will sometimes do so. There are many retouching mediums on the market, and it is possible to buy at least two grades, the regular for light retouching, the special to be used when heavier penciling is required. A piece of lintless cloth should be merely dampened with the medium and the film rubbed with it, but it is desirable to continue the rubbing until the medium is dry (which is a matter of a few seconds only), as if this is not done the negative will probably show a definite outline where the medium has been applied, this being especially true of an intensified film. It is best to apply the medium over the entire surface of the negative. Generally speaking, an HB or a B pencil will be used, though for special work a harder or a softer grade may be desired. If the work proves

IN THE PATH OF THE STORM
BY THOMAS O. SHECKELL
From a Chlorobromide Enlargement

unsatisfactory it is easy to clean the pencil marks off by means of a cloth dampened in the medium, when the work may be done over again. It is desirable to have a long point to the pencil and this point in general should be kept very fine, a piece of number O sandpaper being useful for sharpening the pencil. It is not necessary to practice any of the special marks used by professional retouchers, such as commas, cross-hatching, etc., for a little care in working will enable the photographer to apply the graphite only where it is wanted, the important point being to work slowly and not attempt to put on too much at once. The negative, of course, should be supported in a retouching desk while work is being done on it, and should be examined by transmitted light, proofs being taken from time to time in order to see how the work is progressing.

Retouching on the Back.—When large areas of a glass negative are to be raised in value or when the lightening is to be great, it is best to apply ground glass varnish or tracing paper to the back of the plate and work on this with pencil or stump. An excellent formula for ground glass varnish is the following:

Gum sandarac..............	90 grains	6.0 grams
Gum mastic.................	20 grains	1.3 grams
Ether......................	2 ounces	60.0 cc.
Dissolve and add		
Benzole..........	1/4 to 1 1/2 ounces	7.5 cc. to 45 cc.

The quantity of benzole added determines the nature of the matt obtained. To apply this the negative is supported in the left hand and a small pool of the

varnish is poured on the back, which, of course, should be thoroughly cleaned and should be free from dust. The negative is then tilted so that the varnish runs all over the plate, the excess being drained back into the bottle from one corner. After some practice it will be possible to flow the negative neatly without getting any of the varnish on the film side or up the worker's sleeve, but any which does get on the film may readily be cleaned off by means of a rag wet with alcohol after the varnish has dried, which it will do in a few seconds. Should the pencil work not be as desired, alcohol will remove the ground glass varnish, and the negative may be flowed again.

If it is preferred to use tracing paper, this should be selected with as fine a grain as possible and of as pure a white as can be obtained. A line about 1/8-inch wide of LePage's or Dennison's glue is run around the edges of the negative on the glass side. The tracing paper, which should be cut slightly larger than the negative, is slightly dampened all over by means of a sponge or a wad of cloth, and is laid on the negative, being pressed down all around so as to insure firm adhesion of the glue. The negative is then set aside until the paper is dry, when the latter will be stretched taut and smooth. Care should be taken not to dampen the paper excessively, or it will expand so much as to split on drying. A sheet of matt celluloid may be used instead of tracing paper, and in the case of a film negative, it is to be

preferred. When celluloid is used, it should be attached to the negative only at one end, by means of a narrow strip an inch or two long of Duco cement, or with a piece of lantern slide binding.

Work may be done to an unlimited extent on either the paper or the celluloid, using different grades of pencil as may be desired, even up to 6B, and if it proves unsatisfactory the penciling may be erased with a soft rubber. It should be noted that work on film side of the negative is in contact with the printing paper, so must be done with greater precision than when it is on the back, as in the latter case the pencil lines give a diffused image on account of their separation from the sensitive surface.

If it is desired to darken an area, this may be done by working on the film with a fine-pointed eraser, which should be rather hard instead of the sort known as putty rubber or Artgum. Some workers use the finest grade of automobile valve-grinding compound, mixed with water instead of oil, applying this either with a manicure stick or with a cloth wrapped around the finger, according to the size of the area that is to be reduced. Also, an etching knife is sometimes used, though this requires a high degree of manual dexterity unless the purpose is entirely to remove a part of the emulsion from the support.

If an enlarged negative is to be made, and areas are to be darkened, the easiest way is to make the intermediate transparency on Adlux or Translite

film, since these are coated on matt celluloid which takes penciling very readily. When this is done, it is best to make the transparency the same size that the finished negative is to be, and to make the negative from this by contact printing; if a negative is made by projection from such a positive the diffusion will probably be excessive. It is, however, possible to eliminate the diffusion due to the matt surface of the celluloid, by varnishing the positive. Any good varnish, such as Valspar, slightly diluted with turpentine, is poured into a tray, and the positive, which must be entirely dust-free, is dipped into the varnish, drained, and allowed to dry in a dust-free place, when it will be found that the matt appearance has entirely disappeared. Of course this will not blend the pencil marks. Any attempt to apply the varnish by brushing it on will probably result in a streaky appearance of the positive.

Combination Printing.—It sometimes happens that it is desired to combine portions of two or more negatives, as in printing clouds or figures into a landscape, and there are several ways of accomplishing this.

The first and simplest is to cut a mask the size and shape of the portion to be printed, keeping both pieces of the black paper; namely, the portion which is cut out and the large sheet from which it is cut. The first negative to be printed from is placed in the printing frame with the paper on which the print is to be made, and the portion of it which is not

desired is shielded by means of one portion of the mask. When printing has gone far enough the paper and negative are removed from the frame and the other negative is placed in it, the printing paper being adjusted in register with the second negative. The other portion of the mask is then used to shield the paper from light and the second negative is printed to the proper depth. Obviously this method is applicable only to printing-out papers unless special means are employed for insuring registration, and in any case it is not easy to manipulate the masks with such accuracy as to show no outline at the junction.

When this method is used in enlarging, registration is very easy. A yellow or red filter is placed on the lens of the enlarger, and the first mask is adjusted; the filter is then removed and the unprotected area of the paper is given the proper exposure. The filter is replaced on the lens, the second mask is put in place and the first is removed, when a second exposure is made on that part of the paper which was protected by the first mask.

Another method for securing the same result is to make a print of the entire first negative, then to make a print of the second and to cut out with a sharp knife from this print those portions which are not desired in the completed picture. The second print is then fastened in the proper position on the first by means of a few touches of glue and the whole is copied. The negative so made will probably show

the outline of the second print on the first and this should be retouched carefully. If the scale of the two negatives is different, one or the other must of course be enlarged and a portion of the enlargement must be used. This method will be found simple and satisfactory.

There are numerous opportunities for failure in combination printing, but careful work and precise observation will enable the photographer to avoid them. Care must of course be taken that the scale is the same throughout; that is, if figures are printed in a landscape they must not be too large or too small; and they must have the proper value or there will be a discrepancy between linear and atmospheric perspective. It may seem unnecessary to state that objects printed in a landscape, whether clouds, figures or trees, should be lighted from the same direction as the landscape, but the writer has seen prints in which this precaution has not been taken, the effect being bizarre in the extreme. Necessarily, also, the quality of definition should be the same throughout. It may seem absurd to call attention to these evident facts, but it is necessary that the worker's observation be as precise and accurate as that of any other individual who will be likely to see the picture, since incongruities of any sort will spoil the psychic effect of the work. Ordinary care would of course prevent such violations of unity as the writer has seen in a picture by a well-known worker, where clouds were printed in a marine, the work having

been done with such indifference that the cloud forms were printed directly over the sails of a yacht in the foreground.

Combination printing is not easy to do, but the results often justify the labor expended, and in fact the thorough artist will not consider any amount of labor excessive, provided it affords exactly the effect which he wishes to obtain, it being far better to spend six months in the production of one satisfactory picture than to make a hundred mediocre ones in the same time. Michelangelo is credited with having said to a person who remonstrated with him for giving so much attention to trifles: "Trifles make up perfection, and perfection is no trifle." Whether or not the great Italian ever actually said this, it is nevertheless perfectly true, and although the writer prefers, whenever possible, to obtain the completed picture from one original negative, it cannot be too strongly impressed on the student that retouching, combination printing, and modification of the print are all necessary at times, and the worker should not permit himself to be influenced by those writers or advisers who maintain that such methods are not legitimate photography. The final result is the only thing to be considered, and the worker's attention should be concentrated on securing the pictorial effect, without, however, introducing any violations of unity resulting from an evident mixture of mediums; that is, photography and hand work.

CHAPTER VII

Enlarging

Reasons for Enlarging.—Many writers say that size has nothing to do with art and that it is possible for a small picture to show as fine artistic quality—that is, composition of line and mass and esthetic feeling—as can be found in a large one. This is perfectly true, but the fact remains that pictorial effect depends to a great extent on the size of the picture, and that the larger the print the more likely it is to produce the desired psychic effect on the spectator. This is probably due to the circumstance that the photographer or painter who wishes to produce a psychic impression, that is, to arouse in the spectator some mood or emotion—which is the highest function of art—is necessarily concerned very largely with producing an illusion of reality, the psychic effect being more likely to result if the observer can be deceived into thinking he is looking at the actual objects instead of merely their pictorial representation. Since natural objects are usually large as compared to the observer, it follows that a picture of a tree or a house is not likely to produce an illusion of reality when it is on a small scale, for the observer is obliged, in looking at the real tree or house, to move

his eyes in order to observe the entire object, whereas this does not occur with a small picture. If, however, the picture be 18″×22″ or 20″×24″ it will be necessary for the observer to move his eyes in order to see the entire picture space, and this motion is unconsciously associated with the idea of magnitude. Hence it follows that those artists who are concerned merely with esthetic qualities need not work in large sizes, but the ones whose ambition it is to produce a pictorial effect should make their prints as large as possible without exceeding the natural limitations of the medium. Ordinarily it will be found that the practical limit of size is about 20″×24″, but it is also true that a print 11″×14″ has much greater carrying power than one 8″×10″, the smaller being essentially portfolio prints rather than wall pictures.

Reasons for Making Enlarged Negatives.—During the two decades which have elapsed since this book was first written, several changes have taken place in the attitude of pictorial photographers in general. First, there has grown up a widespread conviction that prints less than 11×14 inches in size are too small for Salon exhibition. Second, the vastly increased popularity of the miniature camera and the tremendous increase in the number of Salons have combined to stimulate pictorial workers to far greater production than was formerly the case. Third, the improvement in chlorobromide papers, which require less technical skill in handling

than do the true bromide papers, has aided the second cause to encourage quantity production of exhibition prints. The result of all this of course is that we now see great numbers of chloride or chlorobromide prints 11×14 inches or larger, whereas we used to see a much smaller total number of prints ranging in size from 4×5 to 8×10, on platinum, gum, or carbon paper.

But factory production methods have no place in art, which demands thought, study, and care, so the quality of our exhibition prints has suffered as the quantity has increased, and this deterioration shows itself not only in the spiritual quality of the work, but in the esthetic quality as well, for the chloride and chlorobromide papers cannot in general compete, in either scale of gradation, richness, delicacy of tone rendering, or beauty of surface, with the finer printing mediums.

Recently, however, signs have been visible to indicate a swing of the pendulum in the other direction, and more and more pictorial workers are growing dissatisfied with the enlarging papers, and are turning to platinum, palladium, gum, Fresson, and carbon. But not many workers are willing to use large cameras, the vast majority of original negatives being from $1 \times 1\frac{1}{2}$ to 4×5 inches in size. It is unfortunately the case that these finer mediums are not adapted to enlarging, but—unless very special apparatus is available—are strictly limited to contact printing. Therefore the photographer who desires

the finest possible results must make enlarged negatives. It is true that bromoil, bromoil transfer, and carbro do not require enlarged negatives in order to produce large prints, but these mediums, though extremely valuable, have their limitations, and few workers find them altogether satisfactory as a complete medium of expression.

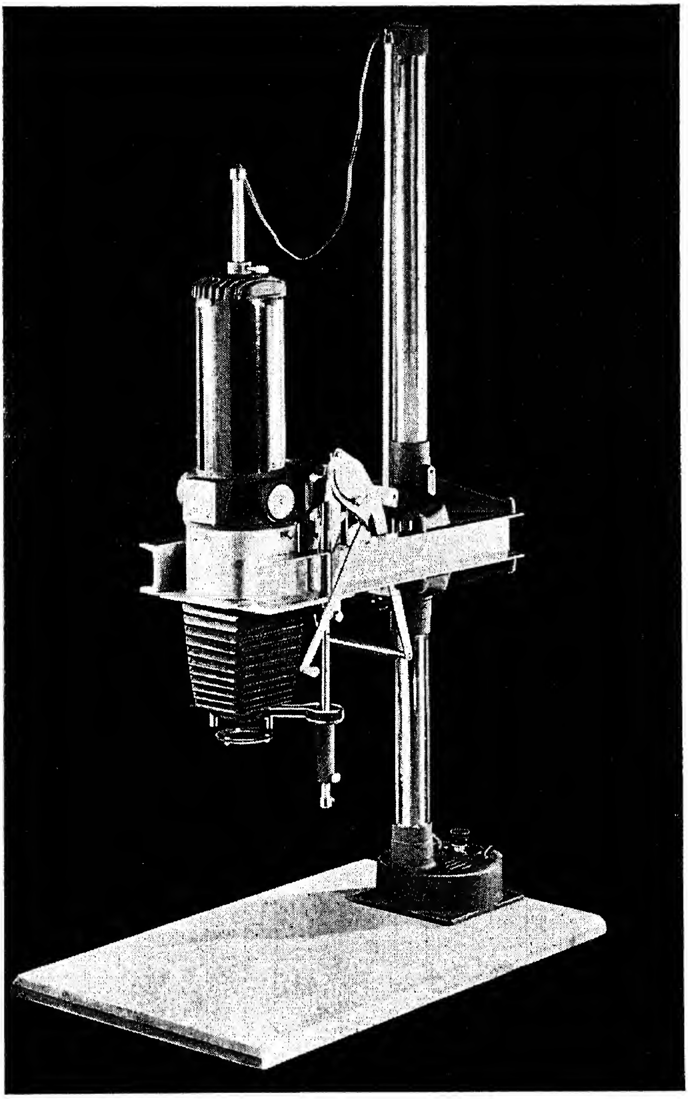
Enlarging Methods and Apparatus.—There is one type of projection enlarger which has attained such popularity as practically to have supplanted all others except for special purposes. This is the vertical type, in which the negative is placed in a horizontal carrier, the image being projected downward on the sensitive material, which rests on a horizontal easel. Further, there are two subdivisions of this type, the auto-focus, in which moving the body of the enlarger to change the size of the image automatically adjusts the focussing, by means of a cam motion attachment; and the non-automatic, which must be focussed by hand each time the image size is changed. And there are two other sub-divisions, one in which the negative is illuminated by diffused light, the other in which condensing lenses are used between the negative and the lamp.

There are far too many different makes of enlarger to permit a detailed discussion of each individual one, so we must confine ourselves to a consideration of certain principles.

First, the auto-focus type is slightly more convenient to use than the other, but it is not capable

as a general rule, of giving as sharp definition with a large aperture of the lens. It is impossible to build, except at prohibitive expense, a truly accurate cam motion, so the manufacturers of this type of instrument give the best general approximation possible, and recommend stopping down to about F/8 when precise definition is required. This of course means prolonging the exposure somewhat, and the question in choosing between these types becomes one of personal preference; the writer finds no very great difference between them in the matter of convenience.

As between the condenser and the diffuser types, a certain group of workers prefers the former because it gives sharper definition than the other. On theoretical grounds this is quite true, but in practice the writer has not been able to see any difference between them, especially for pictorial work, where extreme sharpness is seldom or never desired; the greater accuracy of the condenser type does not begin to show itself until enlargements of ten or fifteen diameters, and of a high degree of technical precision, are required. On the other hand, when condensers are used, any scratches or pinholes in the negative show up much more clearly than with the diffuser type, and further, since the projection lens and the illuminant must be at the conjugate foci of the condensing lenses if uniform illumination of the screen is to be obtained, the lamp must be moved into a new adjustment each time the size of the image is changed. The condenser type, to be



By courtesy of Simmon Brothers

FIG. 40.—TYPICAL MODERN ENLARGER

sure, gives shorter exposures than the diffuser, but on the whole the writer prefers the diffuser type, on the score of convenience.

Some enlargers are built so that a film negative is held between two pieces of plate glass and in some (especially for miniature negatives) a strip of film is drawn through a velvet lined gate to remove dust, the individual negative from which the enlargement is made being supported in air during projection. Both these arrangements are bad, the former because it is almost impossible to clean the glasses without electrifying them and causing them to attract dust, and also because when a negative is held between two plates of glass we are apt to get Newton's interference rings, which show themselves as concentric light and dark circles in the enlargement. The second arrangement is undesirable because any speck of dirt which may be lodged in the gate is likely to scratch the film as the latter is drawn through. Dust and scratches which are of minor importance when enlarging two or three diameters become a very serious matter when enlargements of fifteen or twenty diameters are being made, and a large part of the miniature worker's technique is devoted to avoiding them. Therefore the best type of negative support for miniature films (and it is highly desirable for all enlarging) consists of two metal plates, hinged to open like a book, each plate having a rectangular opening slightly smaller than the negative which is to be used. The film is put into

position, the plates are closed, the dust is blown off with a small rubber syringe, and the carrier and negative are put into the enlarger together.

There are three illuminants in general use for enlarging, the Mazda lamp, the Photoflood lamp, and the mercury vapor (neon or argon) grid, each having its special advantages and disadvantages. As between the Mazda and the Photoflood, the latter gives shorter exposures, but also generates much more heat, so that if many prints are being made from one negative, or if for any reason the exposure is prolonged, or if the negative is accidentally left in the enlarger with the light on, the film is very likely to be damaged if not entirely destroyed. For this reason it is desirable to have the light controlled by a pedal switch, so arranged that the current is automatically shut off when the worker lifts his foot. Also the Photoflood has a short life as compared to the Mazda, which fact not only involves more frequent replacements but in addition means that the intensity of illumination is more variable, falling off more rapidly hour by hour. The mercury vapor grid has the advantages of being very economical to operate and of being cold, so that there is no danger of injuring the negative even with very prolonged exposures. Its disadvantages are that it must be turned on about fifteen minutes before making the first exposure, since it requires some time to reach its full intensity; that although the light is photographically strong and permits, in general, short ex-

posures, it is visually rather weak, so that arranging the picture and focussing are sometimes difficult; and that it requires from 3000 to 5000 volts of electricity in the enlarging room. If the wiring is properly installed, and if the worker uses due precautions, this involves no danger whatever, and in any case the amperage is so low as not to be at all dangerous to a normal individual; but if the installation is faulty, or if the worker is careless, it is possible to get a shock which would be unpleasant to anyone, and might be fatal to a person whose heart was weak. There has recently been developed a fluorescent tube which operates on relatively low voltages, and this promises well for enlarging, though so far as the writer knows it is not yet on the market in a form specifically designed for this purpose.

There is another kind of enlarger, the fixed focus type, but this is useful mainly for proofing miniature negatives, since it is limited to one degree of enlargement. Also, some workers use a copying camera for enlarging, this being very satisfactory except that it is bulky and expensive, and that it makes sunning down, shading of the enlargement, and combination printing difficult or impossible.

Much larger prints than 20×24 have been made, but extreme sizes generally challenge attention as a tour de force rather than through pictorial merit, and are likely to be, for this reason, somewhat unsatisfactory.

Glass, Paper, or Film Negatives.—Either dry plates, films, or bromide paper may be used for the enlarged negatives, each of these materials having its own advantages and disadvantages.

Bromide Paper.—*Advantages.*—

(1) It is the cheapest of the three materials. The true pictorial worker, however, is not turning out either negatives or prints in quantity lots, so the cost of his sensitive material is not usually vital.

(2) It is lighter, and more compact for storage, than plates.

(3) It is easier to manipulate in the dark-room than either plates or films. This characteristic, though, does not assume any great importance until sizes larger than 11×14 are used.

(4) Values may be lightened directly on the paper with pencil, without the need of retouching medium or of backing with tracing paper or celluloid.

(5) It is impossible to over-develop a negative on bromide paper, since development proceeds as far as the exposure demands, and then stops. Thus one possible cause of failure is avoided.

(6) The texture of the paper support, by being reproduced in the print, sometimes may enhance the pictorial effect. If this texture is not desired, it may be avoided when making the large negative by putting the paper into the enlarger or printing-frame with its back to the transparency, thus printing through the paper. This requires from four to ten times as long an exposure as does the conventional

method, but the texture of the paper, by printing on the emulsion, gives a negative which, though grainy by reflected light, is free from grain by transmitted light.

Disadvantages.—The chief disadvantage of bromide paper is that it has a shorter scale of gradation than either plates or films. Consequently, if the subject is one in which the expression requires either delicacy of gradation or length of scale, or both, bromide paper is not so satisfactory as either of the other mediums.

PLATES.—*Advantages.*—

(1) Printing is slightly more rapid for a given quality of negative than with paper. This, though, is of little importance; many of the writer's paper negatives print on palladium in three or four minutes in bright sunlight, whereas some of his glass negatives require more than this.

(2) Plates are capable of giving somewhat finer detail than paper. This also is of little importance, and may, indeed, be an actual disadvantage to the pictorial worker.

(3) It is easier to manipulate glass plates in printing. If single prints are to be made, this is of little or no consequence, but when multiple printing in any medium is used, it becomes of decided importance.

(4) Should the quality of the transparency not be as desired, it is easier to correct the fault by shortening or lengthening the development of the negative than is the case with paper.

(5) If chemical intensification or reduction is necessary, and especially if the work is to be local rather than general, plates are preferable to either films or paper.

FILMS.—In general, films are light, compact, easy to handle in the darkroom, have good negative quality, and in cost are intermediate between paper and plates. They have one defect which may be extremely serious, namely, that if printed in sunlight or by a carbon arc, the larger sizes tend to buckle in the printing-frame from the heat, giving irregular streaks of light and dark in the print. If printing is by a cool light, such as a mercury vapor lamp, this fault does not appear.

As a rule, the writer prefers to make his enlarged negatives on plates, chiefly because of their superior negative quality and their greater ease of handling when making multiple prints.

TECHNIQUE OF MAKING ENLARGED NEGATIVES.—The writer has encountered, among pictorial workers, an astonishingly widespread superstitious fear of enlarged negatives; there seems to be a general disposition to regard the person who can make an enlarged negative as a sort of magician, a wonder-worker. This is utterly absurd. Anyone who can make an enlargement on bromide or chlorobromide paper can make an enlarged negative; there is no mystery about it, and though care and precision are required, these qualities are no more necessary than

they are in exposing and developing an ordinary film.

There are two basic methods, with minor variations in each, of making enlarged negatives. In the first, a transparency is made by contact printing on a plate or film from the original negative, and an enlarged negative is made from this by projection on a plate, film, or bromide paper. In the second, an enlarged positive is made on a plate, film, or bromide paper, and from this a contact negative is made in one or another of these mediums, according to the effect desired. The first method has the advantage of cheapness, the second of the fact that any required darkening of areas is best done on a positive the full size of the finished print.

Whichever method is chosen, the transparency should in general possess certain very definite characteristics if the quality of the original negative is to be maintained in the enlarged one. Exposure and development should be so adjusted that the shadows of the positive are fairly strong without being blocked up, while the extreme highlights have a decided deposit of silver in them. The beginner usually aims at the quality which would be correct for a lantern-slide, but for the present purpose this is far too thin; unless the highlights are much lower in tone than those of a slide, it will be impossible to hold these gradations in printable quality in the large negative. The quality of the transparency is of much more importance if the enlarged negative is

to be on paper than if it is to be on a plate or a film, the possible control by variations of development time being far greater with either of the last two mediums than with paper.

If paper is used, it should obviously be single weight, for the sake of speeding up the printing time, and if the texture of the support is to be retained in the print, this texture should of course be uniform. If the texture is to be canceled out by printing through the support, as mentioned on page 156, uniformity is not so important.

One technique which the writer often uses is described below; he does not, however, claim that this is necessarily the best, but merely that it is one which he finds very convenient and satisfactory for the type of work that he wishes to do.

When an enlarged negative is planned, the small original is made decidedly soft, by shortening development. From this an enlarged positive (usually 11×14) is made by projection on Adlux or Translite, these being celluloid films, matt on both sides, and coated on both sides with a chlorobromide emulsion. In making this positive, the exposure is determined by making a test exposure or two on a chlorobromide paper of the same speed, giving time enough to render the lights as they should be for a print; the film is then exposed four times as long as the test sheet, thus insuring that the positive will have sufficient depth in the thinner portions. The positive is then fixed, washed, and dried in the usual

manner, being swabbed with a windshield wiper, as described on page 113, to prevent spotting by standing drops of water.

Since the film is coated on both sides, this positive will probably have far more contrast than could be rendered in any printing medium, but the gradations throughout will be fully preserved. Any requisite spotting or other pencil work is done on the dry positive, and the negative is made by contact printing.

The positive having too great a degree of contrast for printing, the problem is to reduce this contrast and at the same time preserve the gradations. Therefore the negative is made on a medium-speed, double-coated plate such as the Standard Orthonon, the Seed L Ortho Non-Halation, or the Eastman D. C. Ortho, when, by giving exposure enough to render the shadows, and cutting down the development time (and generally using a rather dilute developer) the gradations at both ends of the scale are rendered, while the total contrast is brought within the desired printing range.

This technique recommends itself not only because it is easier to hold the gradations and quality of the original by this method than by some others, but also because there are great possibilities for throwing the emphasis toward one end or the other of the scale by under- or over-exposing either the positive or the negative and by under- or over-developing the negative. And in addition, the two matt

surfaces of the positive will, if desired, take penciling to an absolutely unlimited extent.

If it is desired to build up the contrasts of an excessively soft original, the transparency is made as described above, and the negative is made from it by carbon printing, using the Autotype Ivory Black tissue, printing from two to ten times as long as would be done for a print on paper, and transferring to ground glass. In this case there is no need to give the ground glass a gelatine coating, as is done in making transfer paper; the carbon tissue will adhere perfectly to the rough surface. This avoids the uncertainty of exposure and development resulting from the use of a dry plate, since the carbon reproduces automatically the gradations of the transparency; the building up of contrast is entirely within the latter. Sometimes, for special purposes, the transparency is made by contact printing from the original negative, and when this is done the carbon process is usually employed, since here again, the process being automatic, one element of uncertainty is removed. In this case it will probably be found that the ground glass introduces an excessive amount of diffusion in the large negative, but this can be avoided by flowing the transparency with any good, clear varnish, which eliminates the matt texture.

An excellent combination for making enlarged negatives is found in Eastman Duplicating Positive Motion Picture Film No. 1355, and Eastman Duplicating Negative Motion Picture Film, Fast, No. 1505.

These films are about the speed of a fast chloro-bromide emulsion, and can safely be handled with a Wratten OA safelight. They are stocked only in 35-mm. size, but can be obtained in any cut size, on special order, in from ten days to three weeks. Since the gamma of the final negative is the product of the gammas to which the two films are developed, and since better quality is obtained if the positive is made strong and the negative soft than if the reverse is the case, it is advised to develop the positive to a high degree of contrast and to keep the negative soft, the Eastman formulæ D-16 and D-76 being recommended, respectively. For characteristic and time-gamma curves, and for details of development, the reader is referred to the Eastman Kodak Company's book, Motion Picture Laboratory Practice, pages 55 to 59.

ENLARGED NEGATIVES BY REVERSAL.—A very rapid, convenient, and satisfactory method of making enlarged negatives is by reversal, as suggested by Crabtree and Matthews in their book, Photographic Chemicals and Solutions. Three solutions are made up, as follows:

Developer

Water	32 ounces	1000.0 cc.
Sodium sulfite anhydrous	710 grains	48.8 grams
Hydroquinone	355 grains	24.4 grams
Boric acid crystals	82 grains	5.6 grams
Potassium bromide	38 grains	2.6 grams
Sodium hydroxide (caustic soda)	355 grains	24.4 grams

Bleacher

Water	32 ounces	1000.0 cc.
Potassium bichromate	130 grains	9.6 grams
Sulfuric acid cp	3 drams	12.0 cc.

Clearing Bath

Water	32 ounces	1000.0 cc.
Sodium sulfite anhydrous	1320 grains	90.0 grams

The sequence of operations is as follows:

Expose (somewhat longer than for ordinary development).

Develop 45 seconds to 1 minute.

Rinse in two or three changes of water.

Bleach 30 seconds (the progress of bleaching can be clearly seen, and should be thorough).

Rinse as above. Turn on white light (100-watt Mazda).

Clear 30 seconds to 1 minute.

Rinse as above.

Redevelop thoroughly in the original developer.

Wash ten minutes in running water. Fixation is not necessary.

The writer is not prepared to state that this method is applicable to all emulsions, but he has used it successfully with such different materials as various chlorobromide papers, Adlux and Translite, Defender Pentagon (a medium-speed orthochromatic emulsion) and Defender XF Pan (a fast panchromatic emulsion). The times given above are for the usual bromide or chlorobromide paper, and when using Adlux or Translite, or the more heavily coated negative materials, will probably have to be increased from two to five times. Plates cannot, in general, be used with this technique. It is obvious that the final negative image is the complement, in silver deposit, of the positive image, so that if correct

densities are to be obtained, the coating of the emulsion must be uniform. And though it is possible to coat films and papers uniformly, this has never been accomplished with plates.

There are several points to be noted with regard to this technique. (1) When an ordinary paper is used, the gradations of the original negative are held rather closely, but with Adlux or Translite the tendency is to build up contrast; therefore, for these latter materials, the original negative should be kept soft. With the negative emulsions, the tendency is to soften contrast, but here a great deal of control is possible through varying exposure and development. (2) Since this is a reversal process, *longer* exposure means *thinner* negatives. Longer development gives thinner negatives, but more contrast. (3) The second exposure to white light should be thorough; two or three minutes is not excessive. (4) When the ordinary negative materials are used, the original exposure must be very much longer than would be the case if such materials were being used in the customary manner, to make either a positive or a negative. For example, a certain negative of the writer's, when enlarged on an average chlorobromide paper, required 10 seconds exposure, but when an enlarged negative was made on Pentagon (which is nearly one hundred times the speed of the paper) it required 40 seconds. A friend of the writer, Dr. A. K. Aster, has used this technique with great success to make direct lantern slides from copies. He

employed Panatomic X film, and found that whereas his exposure for a negative would be, in certain circumstances, about 1 second, in the same circumstances to get a satisfactory slide it was necessary to give five minutes exposure. Even so, the method represents a considerable saving of time, for it was found possible to get a roll of eight slides in less than an hour of time, which could not be done with the usual technique. The method was found to work equally well with line and with continuous tone subjects.

In addition to the obvious saving of time and money which this technique offers, it is considerably easier to hold the gradations of the original subject than is the case when an enlarged negative is made in the customary manner.

Bromide Enlarging.—The shortcomings of bromide and chlorobromide papers, as compared to the finer printing mediums, are as follows:

(1) They have a relatively short scale, and consequently do not render the more delicate gradations of the negative so beautifully as do platinum, palladium, carbon, gum-pigment, or Fresson.

(2) They do not give as rich blacks as can be secured with other mediums.

(3) Their surface texture is not so pleasing as that of various other papers.

(4) Unless redeveloped to a brown color by the sulfiding process (or its equivalent, hypo-alum ton-

ing) they cannot be considered so absolutely permanent as the finer mediums.

In general, we may say that by comparison with the better printing methods, the esthetic effect of bromide or chlorobromide paper is rather thin and uninteresting, but if the worker is prepared to accept their limitations, these papers undeniably offer a quicker and easier method of making large prints than does any other.

Bromide and chlorobromide papers are manufactured in a wide variety of surfaces, speeds, and degrees of contrast, and in several different tints of support, such as white, ivory, buff, and so on. As a rule, the surface textures are commonplace and uninteresting, some of them even being definitely ugly, but there is one make in which very beautiful paper stocks are used. This can sometimes be of great value to the pictorial worker, when the interest of the picture lies chiefly in the upper and middle tones, extreme richness of blacks not being demanded. And there is one foreign paper with a surface texture practically identical with that of Fresson.

In making direct enlargements, it is important to have the quality of the negative adjusted to the paper which is to be used, for although a certain amount of juggling is possible in order to vary the contrast of the print, this is not as a rule advisable. Soft prints may sometimes be got from negatives of excessive contrast by giving three or four times normal exposure, using a dilute developer, and arrest-

ing development in an acid bath when the print has reached the desired depth. This works better with some papers than with others, but in general it is not advised, being likely to result in granular prints of an unpleasant color. In the main it is better to intensify or to reduce the negative in order to adapt it to the range of the paper chosen, and it should be remembered that better quality (that is, better rendering of the gradations of the negative) is obtained when a strong negative and soft-working paper are used in combination than when the negative is weak and a strong-working paper is used in order to get sufficient contrast. If the full value of the paper is to be obtained the negative should be of such quality that normal treatment will just give the desired quality in the lights and at the same time will give the darkest shadows which the paper is capable of rendering. In other words, it should exhaust the scale of the paper, for bromide paper is not a long scale process, and does not, normally, give as strong shadows as platinum or carbon. If the print is to be redeveloped, however, the negative should not be too strong, for the shadows must not be blocked up, any suggestion of reversal—from over-exposure—giving a poor color.

Practically any developer may be used, though it is advised to employ that recommended by the manufacturer of the paper in use, and it may be noted that a strong amidol developer tends to give a cold black. Pyro is not generally recommended, on ac-

count of its staining tendency, though if carefully used it may be made to give a very pleasing warm color. Generally speaking, the developer should be used rather strong, especially if the print is to be redeveloped. An acid fixing bath with hardener is generally advised, particularly if the print is to be redeveloped, since this operation tends to cause blisters or frilling. Washing should be thorough, for on the removal of the products of fixation depends the stability of the print, and it is imperative that all the hypo be removed from the emulsion of a print intended for redevelopment, since any hypo remaining in the film will combine with the potassium ferricyanide in the bleacher, forming Farmer's reducer, which will dissolve out portions of the silver image, spoiling the print. The fixing bath should be renewed at frequent intervals, for it will apparently work satisfactorily after it has actually ceased to do so, and an exhausted fixing bath is prejudicial to the stability of the print. Most of the present-day enlarging papers have been so hardened in manufacture that a hardening hypo bath is not necessary in order to prevent blisters, and the writer prefers to use the standard stop bath of acetic acid to arrest development, and to fix in a freshly mixed plain hypo bath, thus insuring that the hypo is never exhausted. Should a paper show any tendency to blister with this treatment, blistering may be avoided by putting the trayful of prints and hypo into the sink and running the wash water in from a hose, without

pouring off the hypo; by this means the hypo is diffused out of the gelatine gradually rather than abruptly, and does not tend to loosen the emulsion from the paper.

A bromide print will not over-develop, the development proceeding as far as the light-action calls for and then stopping, development usually requiring from two to three minutes—depending on the paper and the developer—and if the print is to remain black and white it is sufficient to develop until the desired depth has been reached—allowing for the facts that the print will look darker when dry than when wet and that it looks darker in the dark-room than it will in full light—and then fix. But if the print is to be redeveloped it is necessary to insure that all the light-affected silver has been reduced to the metallic state (which cannot be determined by inspection) and this is accomplished by continuing development for as much longer as is required for the print to assume the proper appearance. That is, if development is complete and has stopped in two minutes, the print should be developed for a total of four minutes. Longer development will do no harm unless the dark-room light is so strong as to cause light-fog, or the developer is of such a character as to produce chemical fog or stains. A print intended for redevelopment should be a trifle darker in its original state than it is to be when finished.

When making bromide enlargements in a very

high key, such as sunlit snow scenes, where the quality in the lights must be absolutely perfect, it is difficult to attain the necessary precision of exposure and development if the prints are judged in the darkroom light. In such cases it is better to make them very slightly too dark, and after they are fixed take them out into a well lighted room and lighten them to the desired point with a very weak solution of Farmer's reducer.

Enlargements (or contact prints on a gaslight paper) should not be left in the hypo too long, or they may bleach to some extent. Ten minutes' fixing is long enough if the hypo is fresh and the prints are moved around in the bath.

If the normal black image is not satisfactory, the print may be given a warmer color by toning, and there are many formulæ for this purpose, the production of brown, blue, green or red tones being possible, some workers having even produced prints in variegated colors. However, most toning methods except those which depend on the conversion of the image into silver sulfide, giving a brown color, tend to diminish the stability of the print, sulfiding, on the other hand, increasing this stability. Sulfiding may be accomplished by the hypo-alum toning method, but a quicker, more convenient, and equally good process is as follows: After fixing and washing—and drying, if desired—the print is immersed in

Water	32 ounces	1000.0 cc.
Potassium ferricyanide	1¼ ounces	37.5 grams
Potassium bromide	1¼ ounces	37.5 grams
Potassium oxalate	3¼ ounces	97.5 grams
Acetic acid glacial	2 drams	5.5 cc.

This should be made up fresh for use, the strength not being important, as the only effect of using the bleacher more dilute is to make it act more slowly. In this solution the print will bleach, and the action should be continued until all the black of the image has disappeared, though a residual brownish image will remain. The print is then rinsed several times to free it from the bleacher and is immersed in

Water	16 ounces	500 cc.
Barium sulfide	150 grains	10 grams

This will not form a perfect solution, but may nevertheless be used. The print will redevelop in this solution, assuming a warm brown color, and should be allowed to remain until all the original detail has returned, when it is washed for a few minutes, swabbed with a tuft of cotton, given a final rinse under a stream of water, and put to dry. Barium sulfide is preferable to the generally recommended sodium sulfide, both because it tends to give a cooler brown and because it keeps better than the sodium salt, a partly decomposed sample of sodium sulfide giving a poor color. The solution should, however, be made up fresh for use. If the color given by this method is too warm, a cooler effect may be secured by using the bleacher very dilute and arresting bleaching when only partially completed, by rinsing

the print quickly in water, the subsequent operations being the same as in the other case. If this is done the final image will consist partly of black metallic silver and partly of brown silver sulfide, the exact color depending on the extent of the bleaching. Some workers find it difficult to secure uniform bleaching when using this method, but if the print is dried before bleaching there should be no trouble. An alternative method is to bleach fully, to redevelop partly in a very dilute non-staining developer, and to complete redevelopment in the barium sulfide solution, the final image in this case also consisting partly of metallic silver and partly of silver sulfide. This method should not be used in a room where films or papers are stored, as the sulfur fumes tend to fog sensitive material. If the local water is above 70 ° F. (21 ° C.), after redeveloping rinse thoroughly, and harden the print for five minutes in

Water....................	32 ounces	1000 cc.
Sodium sulfite anhydrous...	110 grains	4 grams
Acetic acid glacial.........	1 dram	5 cc.
Potassium alum...........	110 grains	4 grams

before washing. This will prevent blistering of the emulsion.

Very fine blue tones, suitable for marines and snow scenes, may be obtained on various chlorobromide papers by toning with gold, and probably without injuring the stability of the print, since the process involves simply a gold-plating of the silver image. Prints to be toned thus should preferably be

developed to a warm tone, adurol (chloro-hydroquinone) being advised for this purpose. A good general formula is:

Water	16 ounces	500 cc.
Sodium sulfite anhydrous	145 grains	10 grams
Adurol	32 grains	2.5 grams
Sodium carbonate anhydrous	145 grains	10 grams
Potassium bromide	7 grains	0.5 gram

Greater warmth is obtained by over-printing and under-developing, with less danger of uneven development than with most developers.

The toner is:

Solution A

Water, distilled	15 ounces	425 cc.
Gold chloride	15 grains	1 gram

For use take

Water	10 ounces	425 cc.
Thiocarbamide	10 grains	1 gram
Sulfuric acid c.p.	15 drops	22 drops
Solution A	3 ounces	130 cc.

This will tone 6 prints 11×14 inches, and may be used at 85 ° F. (30 ° C.) if the prints have been well hardened. Toning is continued until the print has attained the desired color, after which the print is thoroughly washed. It should be noted that this method has a marked intensifying action, so the original print should be somewhat lighter than it is to be when finished.

Whether the prints are black or brown the richness of the shadows and the brilliance of the lights are greatly increased by varnishing. If it is desired to varnish without changing the color of the print,

French picture varnish diluted with alcohol may be used, the print being dipped into this and hung up to dry. If a slight yellowing of the print is not objectionable, Old English Floor Wax may be used, being applied with a brush or rag and polished with a moderately stiff brush, the final polish being given with a soft cloth. This improves the appearance of a strong print to a marked degree. Simoniz wax may also be used, or 2-in-1 shoe polish, the former giving a faintly greenish tone to the print.

PART III

PRINTING METHODS

CHAPTER VIII

The Ideal Medium

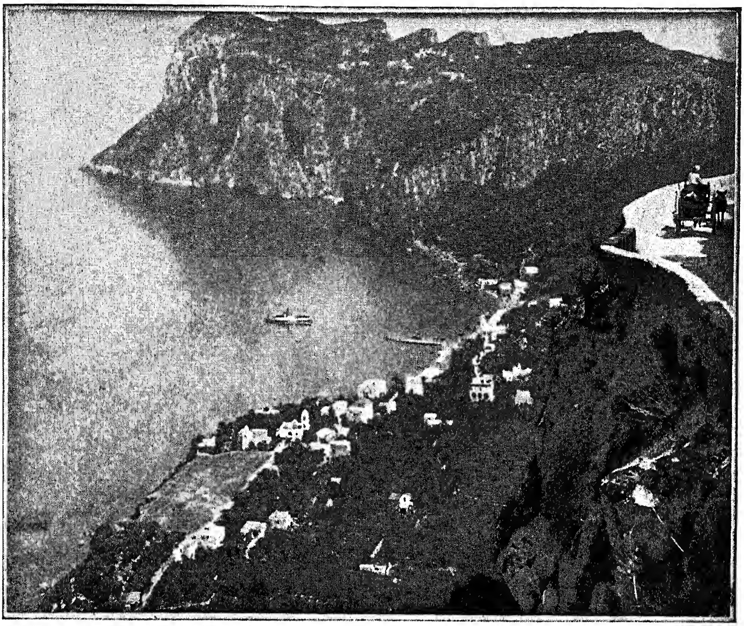
No printing medium possesses all the characteristics which are desirable, and the selection of the medium in which the negative is to be rendered must therefore depend on the particular qualities that are to be secured in the completed picture. Thus, some mediums will render the lighter gradations satisfactorily but fail to give good quality in the lower register, whereas others are satisfactory in shadow rendering but fail to give good quality in the lights. Also, some mediums which render gradations nicely do not possess a pleasing surface texture, while others which have a good texture fail in the rendering of the tones of the negative. The present chapter will give so far as possible a discussion of the characteristics which the ideal medium should possess, and in the next chapter the different mediums will be considered with reference to the advantages and disadvantages of each.

PERMANENCE.—If pictures are made for sale necessarily honesty demands that they should not be likely to deteriorate in the course of time as the result of exposure to light and air. All of the mediums considered in this book possess this characteristic except

that the pigment mediums may be fugitive if improper pigments are used and that a black and white bromide print cannot be considered absolutely stable. If, however, the proper colors are selected these mediums may be as stable as an oil painting or a charcoal sketch, and it is known that charcoal drawings are in existence to-day which were made at least 20,000 years ago. Of course, no picture is necessarily permanent, since any may be destroyed, but some mediums are so unstable that the image will partially disappear in the course of comparatively few years, even if carefully treated.

Rendering of Gradations.—The printing medium should be capable of rendering with absolute fidelity all of the gradations of the negative from pure white to pure black. Since these gradations may proceed by imperceptible transitions, it necessarily follows that the paper must be highly sensitive to slight variations of light action, although it is of course possible to make a negative in which the scale of gradation exceeds the power of any printing paper to render, this being due to the fact that the negative is examined by transmitted light, whereas the print is examined by reflected light, and the paper support on which the image rests absorbs a considerable proportion of the incident light.

Texture.—Although the superficial texture of the print has nothing to do with the pictorial effect, which depends solely, so far as the print is concerned, on the rendering of the gradations of the



CAPRI
BY KARL STRUSS
From a Bromide Enlargement

negative, nevertheless this matter of texture is of considerable importance, the esthetic value of the picture depending on it to a great extent. That is, if the surface of the print is of a quality which is inherently unpleasant to the eye, the observer will unconsciously be repelled by it, this feeling of displeasure being at times so great as to impair seriously the psychic effect of the picture. It is generally accepted that a dull surface is more pleasant to the eye than a glossy one, though for some effects a lustre may be preferred, and it is also usually the case that a slight roughness is more agreeable than a smooth surface, especially if the roughness is irregular in character.

Modifications of Color.—Photography is essentially a monochromatic art, although at times variations of color are introduced. Still, the color chosen for a picture may be of great importance as regards the pictorial effect, as will be realized if we consider the result of printing a snow scene in brown. The prevailing tone of a summer or autumn landscape is generally warm; that is, tending toward yellow or red rather than toward blue; and that of a spring or winter landscape is generally cold. If an unsuitable color is used for printing, it will be difficult to produce the desired illusion of reality, and the printing medium should therefore be flexible in this respect, though it is generally desirable to avoid the more pronounced colors, such as blue, green, and red, and to confine oneself to cold, neutral, and warm black

and to various shades of brown. If the worker's aim is merely to produce an esthetically pleasing result and no value is attached to the illusion of reality, a neutral black will generally be found most satisfactory.

Modifications of Relative Values.—It should be possible within limits to modify relative values in the print, since it is often inconvenient to make in the negative the changes necessary to pictorial effect. This, however, is not of great importance, for such changes can always be produced in the negative if the worker will give the necessary time and effort, and the power of modifying values in the print may sometimes constitute a positive disadvantage, the worker being apt to be led astray by this flexibility and to do more than should properly be done.

Modifications of Total Contrast.—It is important that the printing medium should be readily controlled as regards total contrast; that is, the difference between the extremes of light and dark, since it is often inconvenient and sometimes impossible to intensify or reduce the negative in the desired manner. Of course if one were always sure of producing the proper quality of negative and were always sure of making the final print in the medium chosen, this flexibility in the printing medium would be of no importance, but it is obviously impossible to be certain of always obtaining the proper degree of contrast in the negative and it not infrequently happens that the photographer will ultimately decide on a

different printing medium than the one originally selected, so that the ability to control the contrast in the print is of no slight consequence. It is true that greater contrast may be secured by printing slowly, whatever the medium may be; that is, a print made in the shade will always show more contrast than one made on the same paper from the same negative if printed in direct sunlight, but practically this method of variation is limited in its application. The writer has known of a satisfactory print being got from an exceedingly soft negative by printing far away from a window, the actual printing time being forty-eight hours, whereas printed in direct sunlight the negative in question would have required not over twenty seconds, but it is seldom convenient to make use of any such prolonged exposure as this, and the ideal medium would permit of the desired result being obtained more readily.

Convenience.—Convenience and rapidity of manipulation are not so important to the pictorial worker as to the commercial photographer, since the former does not usually wish to turn out prints in quantity, being more concerned with the production of a few pictures of high quality. Other things being equal, however, the more convenient method is to be preferred and it is regrettable that the finest printing mediums (with the exception of bromoil and carbro) require either daylight or else a very powerful artificial light such as the carbon or mercury vapor arc, many amateurs who do exceedingly

fine work being so situated that their daylight hours for working are limited to Sundays and holidays.

Duplication.—One of the advantages of photography over most mediums of expression is the faculty of duplication, whereby any number of identical or closely similar prints may be made from a satisfactory negative, and although this power is of more value to the commercial than to the pictorial worker, nevertheless it is by no means to be ignored by the latter, and it is to be regretted that with the finer pictorial mediums duplication is not easy unless the prints are made at the same time. If extensive local work has been done in gum or oil, it may be impossible to repeat a success.

CHAPTER IX

Discussion of Various Mediums

The following chapter will give a discussion of the advantages and disadvantages inherent in the more desirable pictorial mediums, namely, platinum, palladium, carbon (single and multiple), carbro, gum, gum-platinum, oil and bromoil (including transfer), photogravure, and Fresson. It should be understood that all of these except carbro and bromoil are contact printing mediums, requiring a negative the same size as the final print.

PLATINUM.—Commercial platinum paper is no longer on the market, so the worker who wishes to use this medium is now obliged to sensitize his own paper; this task, however, presents no difficulties, being one of the easiest and simplest of all photographic operations. In addition, the hand-sensitized paper has several marked points of superiority over the commercial product which was formerly on the market.

Advantages.—(1) The manipulation of platinum is much easier than that of any other pictorial medium.

(2) Platinum renders gradations in the lights better than does any other medium, and in the half-tones and shadows as well as most of the others.

(3) Modifications of color ranging through neutral and warm black, brown, and sepia are readily obtained.

(4) Modifications of total contrast are very easily made, platinum being more flexible in this respect than most other mediums.

(5) Multiple printing, to increase contrast or to secure greater richness in the shadows, is extremely easy.

(6) The superficial texture is esthetically pleasing, since the image consists of a deposit of fine particles of metallic platinum among the fibres of the paper, no gelatine emulsion being used, for which reason the surface is lustreless.

(7) Practically any texture or weight of paper stock may be used, from a tissue to the heaviest linen paper.

(8) Duplication of results is comparatively easy.

Disadvantages.—(1) It is not easy to introduce local modifications of values, it being in fact almost impossible to do this except by the laborious and somewhat unsatisfactory process of brush development with glycerine. The chief fault to be found with brush-developed platinums is that they usually look like wash drawings rather than like photographs, though it must be admitted that the writer has seen some very fine, and purely photographic, prints that were made in this way.

(2) Platinum printing is relatively somewhat expensive.

Palladium.—The advantages and disadvantages of palladium are the same as those of platinum, except that it is a trifle less easy to control the contrast and the color of a palladium print, and that, at current prices of the two metals, printing in palladium is very much cheaper than when platinum is used.

Carbon.—*Advantages*.—(1) Carbon renders shadow gradations as well as any other printing medium and better than most.

(2) Any one of about fifteen different colors may be used.

(3) It is fairly easy to make modifications of relative values in the print.

(4) It is easy to make modifications of total contrast, by multiple printing.

(5) By multiple printing in different colors some very beautiful effects are obtained which are quite beyond the power of most other mediums to secure; thus for portrait work if a rather strong print in red chalk be put on a yellow paper and over this a comparatively light print in ivory black the result will be that the extreme lights will have a yellow tone, ranging through orange, red, and warm black to neutral black, this being a very desirable quality of print for portraiture.

(6) Any color and practically any texture of paper support may be used.

(7) A good carbon print, especially a multiple print, has a richness in the shadows which approximates that of an oil painting, this being due to the

fact that the emulsion has appreciable thickness, so that the observer has the sense of looking through a layer of pigment instead of merely at it, as is the case with most printing mediums.

(8) Duplication of results is comparatively easy.

Disadvantages.—(1) It is not very easy to modify total contrast in single printing.

(2) The process is somewhat laborious to handle.

(3) It is almost impossible, except in the case of prints in a very high key, to secure a lustreless surface.

(4) The process is difficult to handle in hot weather or in a very dry atmosphere.

(5) Pure highlights are not easily obtained except by means of hand-work on the print.

(6) The gradations in the extreme highlights are not rendered so well as with some other mediums.

CARBRO.—The advantages and disadvantages of carbro are practically the same as those of carbon, with the following additions.

Advantages.—(1) Large prints may be made from small negatives without the need for an enlarged negative.

(2) Multiple printing is much easier with carbro than with carbon, since there is no need for registration, this being entirely automatic.

(3) When single printing is used, there is much more control over the total contrast of the prints.

Disadvantages.—The process is much more ticklish than carbon, requiring greater precision and care,

and being much more likely to go wrong from no apparent cause.

GUM.—*Advantages.*—(1) The choice of color and texture of paper support is practically unlimited.

(2) Practically any desired color or combination of colors may be secured.

(3) Modifications of relative values are made more easily than in any other medium except oil and bromoil and quite as readily as in these.

(4) Modifications of total contrast are comparatively easy to make in single printing and the possibilities in this direction are unlimited if multiple prints are made.

(5) In single gum printing a practically lustreless surface may be obtained.

Disadvantages.—(1) By reason of its great flexibility gum is probably the most difficult printing medium to master completely.

(2) Single gum is a very short scale medium and does not render shadow gradations or light gradations satisfactorily, its value being confined to the middle register. These objections, however, are overcome in multiple printing.

(3) There is a looseness of texture in a gum print which militates against the rendering of extremely fine detail, this being due partly to the character of the coating and partly to the fact that it is impossible to secure a gum print on a perfectly smooth surface, a slight superficial roughness being necessary. This, however, cannot be regarded as a disadvantage to

the pictorialist, who rarely if ever wishes fine definition.

(4) Duplication of results is difficult, especially if some weeks have elapsed between making the first and the second prints.

Gum-Platinum.—If a gum print is made over a platinum by coating the finished platinum print with a gum-pigment mixture and printing a second time, practically all the disadvantages of both mediums are overcome, since the platinum print renders the gradations in the lights, which are beyond the capacity of the gum, and the gum print adds the richness and depth in the shadows which may be lacking in the platinum, it being in addition comparatively easy to modify relative values and being much easier to master the technique of the process than is the case with gum alone. For general photographic purposes the writer is inclined to consider gum-platinum as the best printing medium, though special cases may of course demand other methods, and, as will be seen later, oil and bromoil reach a higher level as mediums of artistic expression.

Oil.—*Advantages.*—(1) Any color or combination of colors may be used.

(2) Modifications of relative values may be made with the utmost facility.

(3) Modifications of total contrast are made very easily.

(4) In some respects the superficial texture is very desirable.

(5) A very beautiful quality of richness and depth in the shadows may be obtained.

Disadvantages.—(1) Delicate gradations are not so well rendered as with some other mediums.

(2) It is practically an impossibility to obtain a lustreless surface, since the image consists of an oily pigment superposed on a film of gelatine. The lustre may, however, be greatly diminished by degreasing.

(3) It is somewhat laborious to handle, since an $8'' \times 10''$ print will require fifteen minutes to an hour for the inking alone, to say nothing of the time required for sensitizing, printing, washing, and soaking.

(4) Duplication of results is very difficult, especially if local modifications have been made.

BROMOIL.—The advantages and disadvantages of bromoil are the same as those of oil with the following additions:

Advantages.—It is possible to make prints of any size from small originals without the necessity for making an enlarged negative.

Disadvantages.—The chemical processes involved in bromoil are somewhat more complicated than with oil and there is consequently more chance for failure.

OIL AND BROMOIL TRANSFER.—The advantages and disadvantages of oil and bromoil transfer are those of oil and bromoil, except that transferring presents the advantage of giving a lustreless surface of almost any desired texture, and that it adds a

further complication with consequent additional opportunity for failure.

PHOTOGRAVURE.—*Advantages.*—(1) Practically any color or combination of colors may be used.

(2) Modifications of total contrast are easily made.

(3) There is a very wide range of color and texture of stock available, although it is not possible to make a thoroughly satisfactory photogravure on a very rough paper, the pressure necessary being such as to flatten out any roughness which the stock may possess.

(4) Absolutely lustreless prints may be obtained.

(5) Great richness and depth are easily secured.

(6) Duplication of results is very easy.

Disadvantages.—(1) It is rather expensive.

(2) It is laborious and requires a considerable degree of manipulative skill.

(3) It does not render the gradations in the lights as beautifully as is the case with platinum.

(4) Relative values are not easily modified.

The writer is inclined to favor photogravure when a lustreless surface is required in combination with richness of the shadows, and the rendering of delicate gradations in the extreme lights is not important. If a slight tone in the lights is acceptable the gradations may be well rendered.

FRESSON.—*Advantages.*—(1) Fresson has a long scale of gradation, rendering the half-tones and shadows very beautifully.

(2) Very great richness and depth of the shadows are possible.

(3) The surface is an absolutely matt one of great beauty.

(4) The paper may be obtained in two different colors of stock, in two different textures, and in several colors of pigment.

(5) Modifications of total contrast are easily made.

(6) Modifications of relative values are also very easy.

(7) The process is very easy to work, requiring but little technical skill in handling.

Disadvantages.—(1) The process is somewhat laborious, the finest possible expression of the medium requiring perhaps an hour for the development of an 8×10 print, in addition to sensitizing, drying, and printing.

(2) Absolutely pure highlights cannot be obtained except by brush work.

(3) The surface of the finished print is extremely delicate, requiring great care in handling to avoid injury.

(4) The possible surfaces are limited to smooth and slightly rough, since with a very rough stock the texture of the image would be excessively loose.

CHAPTER X

Technique of Platinum

There is no small amount of superstition prevalent in photography, one of the most conspicuous of the unreasoning dreads of photographers being a fear of platinum printing; there seems to be a general belief that it is an extremely difficult process, to be handled only by a master of technique. This is so far from being a sound belief that platinum is, in fact, quite the simplest and easiest of all printing processes; the writer has known at least one teacher who started his pupils on platinum because it was so much easier to handle than gas-light paper.

THE NEGATIVE.—It is generally stated, by writers on the subject, that platinum requires a strong negative, but this is by no means the case. Platinum is a long-scale process, and to exhaust the scale of the paper requires a stronger negative than is needed to exhaust the scale of a chloride or a chlorobromide paper, but platinum is magnificently adapted to give prints in either high or low key from soft negatives, and some of the writer's films are extremely thin. Roughly speaking, for a given quality of print in platinum the negative would be developed about fifty per cent longer than for the same quality of print on an average chloride paper. As with various

other mediums, for a given degree of contrast, a thin negative gives sweeter prints than a dense one. Platinum renders the gradations of the negative perfectly except in the case of very heavy shadows, in which respect it is perhaps somewhat inferior to carbon.

MATERIALS.—Commercial platinum paper being no longer obtainable, it is necessary for the worker to prepare his own, and for this the following supplies will be needed.

(1) Potassium chloroplatinite. This should be in the form of clean, dry, ruby-red crystals; it must be quite fresh. The yellow chloroplatin*ate* is useless for this purpose.

(2) Ferric oxalate. This must have the form of dry, bright-green scales; if there is any suggestion of a brownish color, or if the scales tend to stick together, the sample must be rejected. Note that the ferr*ous* oxalate is useless for platinum sensitizing.

(3) Oxalic acid.

(4) Potassium chlorate.

These last two should of course be chemically pure, but no trouble is likely to result from staleness.

(5) Distilled water.

For developing, the following will be required:

(6) Potassium oxalate, neutral.

(7) Mercuric chloride. This is needed only if warm black or brown tones are desired.

(8) Potassium bichromate. This is used only to gain extreme contrast, or to clear up the degradation of the lights which occurs in stale or damp paper.

For the sake of convenience, it is well to have three 2-ounce bottles with rubber caps carrying medicine droppers; these droppers should be checked to make sure that they deliver drops of the same size. The bottles should be of brown glass, or should be covered with black paper, since the solutions must be protected from actinic light; if this is done, they will keep indefinitely.

The sensitizing brush must be made without any metal, and for the sake of economy should be thin and short-haired; the best are the broad, flat brushes which are used by Japanese painters and which are sold in Japanese art stores. Two or three inches is a convenient width for prints up to 16×20 inches.

Almost any paper that is neither too absorbent nor too heavily sized, and that will stand soaking in water, may be used. A convenient way to determine whether or not the paper is suitable is to pin an 8×10 sheet by all four corners on a horizontal board, pour on it 3/4 dram of water, and spread this back and forth with the brush; if the water soaks in so fast that it is difficult to spread it evenly, or if it requires more than about 2 1/2 minutes of brushing to soak in enough not to run when the paper is hung up, that particular variety of paper is not advised. Good papers are:

Lalanne or Michallet Charcoal. Strathmore Charcoal works well, but tends to soften up in processing, and must be handled carefully.

Whatman drawing paper, cold pressed, any surface.

Strathmore Alexandra Japan Vellum, white or buff. In general, the plate finish is preferable to the antique, the latter being too soft for any except special effects, or for harsh negatives.

Almost any good linen drawing or writing paper can be used, as well as many other varieties; the writer has seen beautiful prints on various tissues, as well as on the thin, tough paper that is used for wrapping butter. In the interests of permanence, a good grade of rag stock should be used.

It should be noted that the character of the paper makes a very great difference in the result, a soft (i.e., relatively absorbent) paper giving much less contrast with the same sensitizing formula than does a harder one.

Making up the Solutions.—For convenience, the water may be used at 120°F. (50°C.) for dissolving the chemicals, but the solutions should cool to room temperature before being used. Only glass vessels and a glass stirring rod should be used. Make up three solutions, as follows:

(1)	Water, distilled, hot	2	ounces	60.0 cc.
	Oxalic acid	16	grains	1.1 gram
	Ferric oxalate	240	grains	16.0 grams
(2)	Water, distilled, hot	2	ounces	60.0 cc.
	Oxalic acid	16	grains	1.1 gram
	Ferric oxalate	240	grains	16.0 grams
	Potassium chlorate	4	grains	0.3 gram
(3)	Water, distilled	2⅜	ounces	60.0 cc.
	Potassium chloroplatinite	219 (½ oz. av.)	grains	12.2 grams

SIZING THE PAPER.—Not many linen or drawing papers will need to be sized before the first printing, but this may be necessary before the second and third printings, if multiple prints are to be made, since the operations of developing, clearing, and washing are likely to remove the size.

Either gelatine or starch may be used for sizing. If the former is preferred, make up the following:

Cold water.................	4 ounces	110 cc.
Hard gelatine..............	80 grains	5 grams

Allow the gelatine to soak until it is well swollen, then melt in a double boiler and apply while hot to the paper with a sponge or a brush, rubbing it well in.

If starch is to be used, rub a little laundry starch to a cream with cold water, then heat, with constant stirring, until it clears; the result should be about the consistency of heavy cream, and if too thick, it may be thinned down with cold water. It may be used either hot or cold.

It is well to put a pencil mark on the back of the paper before sizing (unless, of course, a print has already been made on the paper, when it is unnecessary) and it is convenient, when sizing new paper, to size it in large sheets, afterward cutting it up for use. Also, if several prints are to be made, it is both convenient and economical to sensitize large sheets, which are later cut to size.

SENSITIZING.—Make up one of the following sensitizers, according to the result desired.

For very soft prints

Solution (1)...........	22 drops
Solution (2)...........	0 drops
Solution (3)...........	24 drops

For stronger prints

Solution (1)...........	18 drops
Solution (2)...........	4 drops
Solution (3)...........	24 drops

For average prints

Solution (1)...........	14 drops
Solution (2)...........	8 drops
Solution (3)...........	24 drops

For strong prints

Solution (1)...........	10 drops
Solution (2)...........	12 drops
Solution (3)...........	24 drops

For extreme contrast

Solution (1)...........	0 drops
Solution (2)...........	22 drops
Solution (3)...........	24 drops

It will be observed that 24 drops of solution (3) are always used; that the sum of the number of drops of (1) and (2) is always 22; and that solution (2) is the one which increases contrast. The quantity given (46 drops) is sufficient for an 8×10 print on a moderately smooth paper; for a rough paper, such as a charcoal or a rough Whatman, 50% more should be used.

It will probably be found that this quantity (46 drops) will give full gradation, but will not give very rich blacks. If these are desired, the total volume of sensitizing mixture may be increased at the time of

sensitizing, or the paper may be sensitized, dried, printed, cleared, washed, and dried, and then sensitized and printed a second or third time, or even oftener; the writer has known as many as seven printings to be put on one sheet of paper. The method used will depend on the effect desired, the second plan tending to increase contrast more than the first.

If the paper is not sensitized in large sheets, it is well to cut it a trifle larger than the print is to be, say 10×12 for an 8×10 print, when the margins may be trimmed off and used for test strips. The paper is pinned down by all four corners on a horizontal board, and the well-mixed sensitizer is poured on it and spread until it has dried enough not to run when the paper is hung up. It is not necessary to use extreme care to spread the solution evenly; moderate avoidance of streaks and puddles is enough. The mixing and sensitizing can be done in any ordinary room, but the paper should be dried in the dark, and should thereafter be handled in moderately subdued light, though a dark-room is not necessary; it is perfectly safe to handle it in an ordinarily lighted room, some distance from the windows and in the shadow of the worker's body.

The sensitized paper is then hung up in the dark to dry, and the writer has not found that the actual drying time, within reasonable limits, is of great importance, though if it is unduly prolonged in damp weather, degraded highlights may result. In ordi-

nary circumstances, it should be fairly dry in ten or fifteen minutes, and should then be made bone-dry over a gas or electric stove, immediately before printing. In drying, great care must be used to avoid scorching, as the sensitizer is injured by heat long before the paper is, and this injury, which is not visible until after development, shows itself as in-eradicable dark areas in the print.

If the paper is not to be used at once, it should be dried and placed in an air-tight container which is sealed with surgeon's (not electrician's) adhesive tape, and which contains a preservative. This preservative consists of a roll of asbestos about the size of a man's thumb, which has been soaked in a saturated solution of calcium chloride, then desiccated over a stove and wrapped in cotton or tissue paper. Or if preferred, the desiccated calcium chloride may simply be stored in a perforated container, such as the small boxes in which spices are sold. This salt is extremely hygroscopic, absorbing moisture readily and keeping the air in the container dry, which is essential to the preservation of the paper. Platinum paper thus stored will remain in first-class condition for three months or more.

Printing.—Platinum paper requires a strong light, such as sunlight, mercury vapor, or carbon arc; if the last named is used, it should be furnished with White Flame rather than Panchromatic carbons. There is on the market a high-intensity mercury vapor lamp, fitted with the necessary reflector and

transformer, and this is excellent for the purpose, since at a distance of twelve inches from the negative it prints more rapidly than unobstructed July sunlight, gives off relatively little heat, and is clean and economical to use. This is sold under the name of the Mazda H-5 lamp.

Platinum paper gives only a slightly visible image, so printing must be by time; for the sake of economy, it is well to use test slips. It is of course impossible to say how long the printing must be, since this depends on the negative, the light, the composition of the sensitizer (a mixture for strong effects taking longer to print than a softer one) the paper (the harder the paper, the longer the printing) and on the effect desired. Perhaps a fair average, in full sunlight, would be five minutes. As with other papers, a platinum print dries down a trifle darker than it appears when wet, and allowance must be made for this in printing. On the other hand, it seems to lighten up a little in the clearing bath, so in general its appearance in the developer is a fair guide to what it will be when dry. Of course, if a record is kept of the printing time, it is an easy matter to correct any faulty estimate of the proper depth.

Development, Clearing, and Washing.—The print should preferably be developed immediately after it is taken from the printing-frame, but if this is not possible, it should be returned to the storage

can to be kept dry. There is no "continuing action," as with bichromated colloids, but any moisture in the air is quickly absorbed by the paper, giving degraded lights.

The developer is a saturated solution of potassium oxalate, made up as follows:

Water, warm	48 ounces	1500 cc.
Potassium oxalate neutral	1 pound	500 grams

In localities where the city water contains a large amount of lime salts, it may be advisable to use distilled water, but this is not as a rule necessary.

This is the basic developer, and is generally used at room temperature; it keeps indefinitely, and should never be thrown away, fresh solution being added from time to time to keep up the bulk. With use, it turns yellow, and a sludge settles in the bottle; the clear solution should be decanted for use.

Three successive clearing baths are used, giving the print five minutes in each; longer will do no harm except in the case of papers which tend to disintegrate when wet. The clearing solution is as follows:

Water	32 ounces	1000 cc.
Hydrochloric acid cp	5 drams	20 cc.

Enough solution should be used so that the third bath remains always water-white, for the permanence of the print depends more than anything else on complete removal of the iron salt from the paper.

Trays should be non-metallic, and if porcelain-lined ones are used, care should be taken to see that

they are not chipped or cracked so as to expose the metal, or spots on the prints may result.

The developer is poured into the tray to a depth of half an inch or more, and the print is slid into this face up, the tray being gently rocked until development is complete, which will take a minute or two; the image flashes up at once on immersion. It is well to leave the print in the developer for two or three minutes, to insure thorough development, when it is drained and transferred to the clearing solution. After going through the clearing baths, it is washed in half a dozen or so changes of water, and is hung up to dry. No special precautions against curling need be taken, as the dry print, once flattened, has no tendency to curl.

At room temperature, it is not necessary to cover the print with an even sweep of developer, but if the developer is used warm, as explained later, this is imperative, any least stoppage of the flow causing an irremovable line of demarcation in the finished print.

Warm Tones.—If warmer tones than the normal black of the platinum image are desired, these may be secured in either of two ways, or by a combination of both.

(1) Slight under-printing, together with a warm developer, gives a warmer toned image, and this may be carried very far; the writer has even used the developer almost boiling. This technique not only gives warmer tones, but also reduces the total con-

trast very markedly. The developer is not injured by heating.

(2) The addition of mercuric chloride to the developer gives warmer tones, the degree of warmth depending on the amount added. It is not possible to give exact instructions as to the quantity that should be used, but a suggested starting point is 60 grains of the salt to a pint of developer (4 grams to 500 cc.). It is the practice of some workers to clear mercury-developed prints in a 1:300 bath instead of the normal 1:50, since they claim that the stronger bath removes some of the warmth given by the mercury. It is unquestionably true that a print cleared in the weaker bath has a warmer tone than one cleared in the strong bath, but Von Hübl has shown that the warmth of a mercury-developed platinum image is not due to the introduction of any other substance, but to the size of the grains of the platinum deposit. Therefore it is the writer's opinion that the greater warmth of the print cleared in the weaker bath is due to imperfect removal of the yellow iron salt, a condition which is decidedly prejudicial to the stability of the print. For this reason, he prefers to use enough mercury to give the desired warmth when a 1:50 clearing bath is used. The effect of the mercuric chloride in the developer does not decrease with use, but if desired it may be diminished by the addition of fresh stock developer.

Increased Contrast.—If more contrast is desired

than can be secured by varying the sensitizing formula, there are three methods available.

(1) Anything which prolongs the time of printing causes an increase of contrast. Printing in a weak light or in the shade instead of in direct sunlight, the use of tissue paper over the printing-frame, or (in the case of artificial light) printing farther from the source of light, will all give greater contrast. In the last instance, it should be borne in mind that the time of exposure varies, not directly as the distance from the light, but (nearly) as the square of the distance.

(2) Over-printing, and the use of a dilute developer, will increase contrast. It is not as a rule advisable to dilute the developer to weaker than half strength, or the prints may have a granular aspect.

(3) The addition of a small quantity of potassium bichromate to the developer, together with over-printing, gives decided increase of contrast. It is impossible to prescribe a definite amount of the salt, but 15 grains to 16 ounces (1 gram to 500 cc.) of developer has a marked effect. In both this case and when a weak developer is used, the over-printing must of course be proportioned to the change in the developer. An excessive amount of potassium bichromate will cause granularity of the image, but very great modification is possible before trouble is encountered. Used in small quantities, this salt is very valuable in clearing up the degradation in the lights that results from staleness of the paper. Unlike

mercuric chloride, the potassium bichromate is gradually used up, and more must be added from time to time to keep up the effect.

DECREASED CONTRAST.—As has already been stated, under-printing and warming the developer will give less contrast, the effect being proportioned to the temperature of the solution.

An alternative method is to add a minute quantity of hydrochloric acid to the developer, a few drops of the 1:50 clearing bath in 16 ounces (500 cc.) having a decided effect.

BRUSH DEVELOPMENT.—If it is desired to practice this method of local modification, the following materials will be required.

A sheet of glass somewhat larger than the print.

A number of lintless blotters.

About 16 ounces (500 cc.) of glycerine.

Several soft brushes of various sizes, not metal-bound.

Three small graduates or other non-metallic receptacles.

The print is somewhat over-exposed, and the sheet of glass, which has been laid flat on a table, is coated with glycerine and the print is laid face up on the glass and brushed over with glycerine. One of the graduates contains glycerine, another developer, and the third a mixture of equal parts of developer and glycerine. The effect of the glycerine is to retard the action of the developer and bring it under control, and development is carried out with the brushes,

using one or another of the solutions as may be required. It is well to work slowly, blot frequently, and use the clear glycerine freely.

The value of this method is directly proportional to the worker's manual dexterity and artistic sensitiveness, and since the average photographer is not overburdened with either of these qualities, the result is generally rather distressing. However, in the hands of an artist the method has distinct possibilities.

Multiple Printing.—This is extremely easy in platinum, and may be used either to build up the contrast of a weak print, to strengthen the shadows, or to obliterate undesired shadow detail.

The finished print is simply sensitized and dried as though it were a new sheet of paper, is placed in register with the negative, and is printed, developed, cleared, and washed as at first. Some papers may need re-sizing before the second sensitizing, and this may be done as described above. To register the second printing, the negative is placed in the printing-frame, and the print is laid on it, held up to a strong, concentrated light such as a 100-watt Mazda, and moved about until the images coincide, when the back is clamped in the frame. Registration will be easier if the negative, rather than the print, is toward the observer. Some papers will shrink in processing, so that it will be impossible to register the entire image; in this case the important part (for

example, the eyes in a portrait) should be registered exactly, and the rest as nearly as may be.

Obviously, either the sensitizing mixture or the printing time, or both, may be varied to suit the effect desired.

SPOTTING.—Some workers prefer to spot platinum prints with water-colors and a fine-pointed brush, but the writer considers this unnecessarily laborious, finding it much easier and equally satisfactory to use an ordinary carbon spotting pencil. The pencil should be kept needle-sharp by means of fine sandpaper, and spots should be touched out by stippling rather than by stroking.

WAXING.—A platinum print may be waxed in order to increase its brilliance or to liven up heavy shadows, as was suggested for a bromide or chlorobromide print. This of course destroys the esthetic quality of the dull surface, and it is sometimes difficult to decide whether or not to wax and polish the print. An improvement in the luminosity of the print may be obtained without the objectionable gloss by waxing and polishing, then melting the wax into the paper over a gas or an electric stove; if the former is used, care must be taken not to set fire to the turpentine with which the wax is mixed. If this method is to be used, the polishing must not be omitted, or the print will probably be streaky.

PALLADIUM PRINTING.—Palladium is a metal of the same chemical group as platinum, which it closely resembles in both chemical and physical character-

istics, and palladium prints cannot be distinguished from those in platinum in any respect; there is no difference in scale, richness, delicacy of rendering, or permanence, though there is a marked difference in expense, palladium costing about half what platinum does.

Sodium chloropalladite is used for sensitizing, formula (3) of page 197 becoming

Water.................	2⅜ ounces	60.0 cc.
Sodium chloropalladite..	162 grains	9.0 grams

The technique of sensitizing, printing, and processing is the same as for platinum, with three minor exceptions.

(1) The normal image of a palladium print is a slightly warm black, instead of the neutral black of platinum. But if greater warmth than this is required, it is best to get it by using a warm developer, since palladium is less sensitive to the use of mercuric chloride in the developer than is platinum.

(2) Palladium is less sensitive than platinum to the use of potassium chlorate in the sensitizer, so it is sometimes necessary to gain contrast by printing in a weak light, or by over-printing and using a dilute developer. However, the amount of potassium chlorate in solution (2) may be increased if desired.

(3) Potassium bichromate cannot be used in the developer, since if this is done, the palladium image will be almost entirely bleached out in the clearing bath.

Palladium sensitizing kits, containing three dropper bottles with enough of the solutions to make twenty or twenty-five 8×10 prints, are prepared and marketed by Baker & Company, of Newark, N. J., and these are very convenient for those photographers who are not prepared to measure and weigh chemicals with a fairly high degree of accuracy.

CHAPTER XI

Technique of Carbon

There is a popular impression to the effect that carbon is a difficult process to handle, but this is by no means the case, for although it is more laborious than platinum, it does not require any high degree of manipulative skill, and calls for less actual labor than gum, photogravure, or bromoil.

THEORY.—If a colloid substance such as gelatine, gum arabic or albumen is sensitized with potassium, sodium, or ammonium bichromate and, after drying, is exposed to light, the colloid becomes insoluble in water. If a dry pigment is incorporated with the colloid and a thin film is spread on a sheet of paper, this film being sensitized and printed under a negative, then, on washing in water, the portions which have been acted on by light will resist the action of the water and remain on the paper, holding their quota of pigment, but those portions which have been protected from light, being soluble, will wash off the paper, taking their pigment with them. Hence there results a print in which the gradations are represented by varying thicknesses of colloid and pigment.

In carbon printing the colloid used is gelatine,

and, since this is in no case soluble in cold water, hot water (about 110° Fahrenheit; 43° C.) must be employed for developing.

THE TISSUE.—The term "tissue" is rather a misnomer, since the paper supplied for carbon work consists of a stout backing which carries a heavy film of gelatine and pigment, the whole being stiff and, when dry, brittle. The tissue is supplied in fifteen different colors, and may be bought either in cut sheets 8×10 inches or in rolls thirty inches by twelve feet. If much work is to be done the rolls are somewhat cheaper, but the cut sizes are easier to handle, since they are packed flat and have less tendency to curl. The tissue should be either bought or cut at least an inch larger each way than the negative to be printed from, this being imperative for multiple printing (as will be seen later) and advisable in any case, since if the tissue is cut to size just before printing it is less likely to give trouble by frilling during the subsequent manipulations than if the edge has been cut for some time.

The tissue is supplied unsensitized, and must be sensitized by the worker. The insensitive tissue keeps for a long time—even for years—if kept cool and dry, but if it is allowed to remain moist, bacteria develop in the gelatine, ruining it. Bone-dry tissue is difficult to handle, and it may be well to allow it to stand in a moist atmosphere for some hours before attempting to cut it.

Sensitizing by Immersion.—Formulae innumerable are given for sensitizing, but the one which the writer prefers is the following, suggested by Mr. Kirtland Flynn, of the Orange Camera Club, and worked out by Dr. A. K. Aster and the writer.

Water, distilled	32 ounces	1000 cc.
Potassium chromate	440 grains	30 grams
Citric acid	q.s. to render solution neutral to nitrazine paper. About 20 grains (1½ grams) will be required.	

The chief fault of the carbon process is the impossibility of getting absolutely pure highlights, there always remaining a slight tone, the gelatine breaking down if development is forced. This sensitizer, however, gives better results in this respect than any other of which the writer knows.

The sensitizer keeps indefinitely, but should be filtered after use. To sensitize, pour an inch or so of the solution into a tray and immerse the tissue, face up, breaking any air-bubbles that may form on either front or back, and keeping the tissue completely immersed. At the expiration of two and a half minutes from the first immersion withdraw the tissue, lay it face down on a clean piece of glass or a clean ferrotype plate, and squeegee lightly to expel the excess of sensitizer. A scraper squeegee should be used instead of a roller, and the kind sold for cleaning windows is the best, the photographic squeegees being too stiff.

If the tissue is to be hung up to dry, no special precautions are necessary beyond having the glass

THE STYGIAN SHORE
BY H. Y. SUMMONS
From a Carbon Print

or ferrotype plate reasonably clean, but as a rule it is better to dry it on the glass or plate, since the surface is thus protected from air, and remains in better working condition. When this is to be done, the glass or plate should be well washed with a mild soapsuds, thoroughly rinsed, and dried with a lintless cloth. It is then dusted with talcum, which is well rubbed over the surface and lightly dusted off, the tissue being then squeegeed to the glass or plate and set aside to dry in the dark. Drying may be hastened by means of an electric fan, and when the tissue is thoroughly dry it will either snap off of its own accord, or may be released very easily.

Sensitizing may be done in an ordinary room, since the tissue is not sensitive until dry, but drying should take place in the dark, for when dry the tissue is at least as sensitive as P. O. P. If the atmospheric conditions are such that drying requires more than eight or ten hours the tissue may show a tendency to become insoluble without exposure to light, and in extreme cases may be quite useless. The sensitized tissue does not remain in first-class condition for more than twenty-four hours, and in the course of a week or ten days becomes entirely useless through insolubilization, even though protected from light and air in the same manner as platinum or palladium. Without this precaution deterioration is more rapid.

Longer immersion or a stronger bath gives a quicker printing tissue and softer prints, briefer im-

mersion or a weaker bath giving a slower tissue and more contrast; but these variations are not recommended, since the results are somewhat indeterminate. The normal bath is a 3 per cent solution, and the sensitizer should in no case be weaker than 1 per cent or stronger than 7 per cent.

Bichromate Poisoning.—Some individuals are allergic to bichromates, contact with these salts producing an annoying and sometimes painful skin irritation, which in extreme cases may be very serious. The writer has never experienced any trouble from this source, but was acquainted with a photographer who suffered for more than a year with a recurrent skin eruption covering the hands, forearms, and part of the face, this eruption being so serious as to prohibit absolutely all photographic activity and almost to incapacitate the individual from any work whatever. Should the carbon worker notice any swelling, redness, or soreness of the fingers, especially around the base of the nails, he should at once abandon the use of bichromate and consult a skin specialist. However, the use of rubber gloves is a certain preventive of trouble, and is to be recommended, since no one can tell whether or not he is allergic except by experience.

Quick-drying Sensitizer.—It is evident that if printing is done by sunlight and sensitizing by immersion, it will hardly be possible to sensitize and print on the same day unless the sensitizing is done early in the morning. But it is possible to sensitize

in such a manner that the tissue will dry within half an hour or an hour, by means of a quick-drying sensitizer which is readily prepared by the worker. To use this sensitizer the tissue is fastened face up on a piece of glass by means of wooden clips at one end, the sensitizer is poured to the depth of half an inch or so into a tray, and is applied to the tissue by means of a Blanchard brush. This consists of a piece of glass with a double thickness of canton or outing flannel folded over one edge and held in place by a string or rubber band. The brush, which should be as long as the long way of the tissue, is dipped into the sensitizer, drained, and drawn several times over the tissue, alternating downward and cross strokes. Firm but not heavy pressure should be used, and if a definite number of strokes is adhered to the printing speed of different pieces of tissue will be alike. The chief danger in brush sensitizing is that streaky prints will result from having the brush either too wet or too dry, and only experience can determine the proper condition. Any unused sensitizer remaining in the tray should be thrown away.

Should the worker desire to prepare his own spirit sensitizer the following method will be found satisfactory:

Stock solution:		
Water....................	4 ounces	125 cc.
Sodium bichromate........	1920 grains	125 grams
For use take:		
Stock solution.............	2 drams	5 cc.
Alcohol 95 per cent to make.	3 ounces	60 cc.

More or less of the stock solution may be used in

order to decrease or increase contrast. The stock solution keeps indefinitely, but the alcohol must be added immediately before use.

PRINTING.—The printing time must be determined by some other means than inspection, since carbon does not give a visible image in the printing frame except in the case of some of the lighter colors, the image even then being too indefinite to serve as a guide. Various forms of actinometer are recommended by different authors, but the present writer finds the simplest method—which is quite satisfactory—to be to make a proof on P. O. P. and to print the carbon tissue for the same time as is required for proofing. This is not quite accurate, since the speed of various batches of P. O. P., even those of the same brand, may vary considerably, and different tissues have different printing speeds, but carbon fortunately has a good deal of latitude, and even serious errors of exposure may be corrected in development. The mezzotint tissues should be printed only half this time, and the Ivory Black only three-quarters, but this method will serve as a guide, and will be found reasonably accurate, at all events in the case of the black tissues. Some workers prefer to take a piece of drawing paper or, in fact, any ordinary white, moderately stout paper, and sensitize this in the same manner as the carbon tissue, drying it in the dark and using this as a test slip. The image prints out on this with a fair degree of visibility, and though the speed is not the same as that

of the carbon tissue (owing to the absence of pigment) it is more uniform than that of P. O. P., and a very few experiments will establish a definite relationship between the speed of the test slip and that of the tissue.

Since the print must be transferred to another sheet of paper (or other support) for development, it follows that it will be reversed as regards right and left if printed in the usual manner. Of course, if the negative is on film or paper it may simply be put into the frame backward and the tissue placed in contact with the back, when the finished print will be the right way round. If the negative is on a glass plate and the print is made from the back some softening of outlines will result if printing takes place in a diffused light, that is, on a dull day or in the shade, but if direct sunlight is used and the frame is not moved during the exposure diffusion will probably not be apparent.

In order that the print may develop satisfactorily, without frilling, it is necessary to provide a safe-edge; that is, a strip of the tissue one-eighth inch or more in width around the margin must be entirely protected from light, and this may be done by the rebate of the printing frame, by a line of opaque run around the edge of the negative, by a strip of passe-partout tape gummed to the negative, or by a cardboard mask. The writer's own practice is to depend on the rebate of the frame in single printing and in multiple printing on a mask, the mask also furnish-

ing a very convenient means for insuring registration of the successive prints. Whatever the form of the mask, it is desirable that it be separated from the tissue by about one-sixteenth inch, a slight vignetting action facilitating the subsequent operations.

Need for Transferring.—Since the effect of printing is to render the gelatine insoluble in inverse proportion to the densities of the gradations of the negative, it follows that as the print comes from the frame it has a layer of insoluble gelatine over the entire surface, except perhaps in the highest lights, the insolubilization extending to different depths in the film, depending on the amount of light that has penetrated the corresponding portions of the negative. Therefore it will be difficult for the hot water to penetrate to the soluble gelatine, and having done so, it will detach the entire film from the paper backing except in those portions where the light has acted clear through the film. If, however, the gelatine film is transferred to another piece of paper so that what was originally the outer layer is now next to the paper, then the water can easily reach the soluble parts, and will dissolve them away without affecting the parts that have been acted upon by light.

Making Transfer Paper.—The transfer paper consists simply of a sheet of paper which has been coated with a film of insoluble gelatine, and may be bought already prepared, but the worker is strongly

advised to make his own, since he may then choose any color and surface texture desired, and in addition to this he will find the home-made paper more reliable than the commercial.

Making the transfer paper is a simple and easy operation, and is carried out as follows. Any paper which does not disintegrate in hot water may be used, though a rather stout one is preferable to a thin, any gelatine-coated paper having a tendency to curl, this being aggravated in carbon work by the varying thicknesses of the gelatine film, so that a thin paper not only curls but also buckles. The coating solution is:

Cold water....................	4 ounces	120 cc.
Nelson's No. 1 gelatine..........	60 grains	4 grams

Allow the gelatine to swell for five minutes and then heat until dissolved. Add a little at a time, with constant stirring

Hot water....................	4 drams	15 cc.
Chrome alum.................	12 grains	1 gram

If the chrome alum solution is cold or is added hastily, or if the gelatine solution is not stirred constantly, the gelatine may coagulate, but it will work equally well in that condition, though it is not so easy to use as when liquid. The mixed solution should be strained through several thicknesses of cheesecloth into a double boiler and should be kept hot while in use. At the end of the day's work the surplus is thrown away. The above quantity will coat approximately three 22″×28″ sheets, depending on the number of coats applied. The gelatine named is relatively expensive, but not actually so, a pound of it having lasted the writer over

three years. However, ordinary cooking gelatine may be used for this purpose, with perfect success, though the better grade is preferable.

It is convenient to prepare the paper in large sheets and cut them to size afterward, but if this is not done pieces at least two inches larger each way than the negative should be coated, since it is necessary that the transfer paper be larger than the tissue. The paper to be coated is pinned by the four corners to a horizontal board, a small, fine-grained sponge is dipped into hot water and squeezed out, and is then dipped into the gelatine solution and rubbed over the paper. The gelatine should be used freely and should be spread over the entire paper, working rapidly and rubbing until the paper begins to show signs of surface-drying, when it may be given a second application and be hung up to dry. By the time the third sheet has been coated the first will be ready for a second treatment, two treatments being sufficient for a smooth paper and three for a rough, a very rough, such as Whatman, requiring four or five. The prepared paper keeps indefinitely without special precautions.

If the sponge is cold enough to chill the gelatine a skin will form, and this may cause a shiny spot on the paper which will show in the finished print. Such a spot may often be removed by vigorous rubbing with the sponge as soon as it appears, but if this does not suffice that portion of the paper should be discarded.

Should the gelatine coagulate on addition of the chrome alum solution it may sometimes be liquefied by raising the temperature, but even if this is unsuccessful it may still be used, though it must then be rubbed into the paper more vigorously than if liquid.

Some bromide and chlorobromide papers may be used for transfer paper, if fixed without exposure to light, hardened, and dried. Some such papers, though, have been given, in manufacture, a super-coat of hardened gelatine to protect the sensitive emulsion, and when this has been done the paper cannot be used as a transfer paper, the gelatine of the tissue refusing to adhere. The Defender Photo Supply Company will furnish certain grades of their Velour Black paper without this super-coat, provided the order specifies "For Bromoil," and this works nicely for carbon. If it is fixed in an ordinary acid alum hypo bath, no additional hardening is necessary. Also, there are several English bromide papers which can be used in this manner.

TRANSFERRING.—A pencil mark is made on the back of the transfer paper and it is then soaked for half an hour (longer can do no harm) in water about 65° Fahrenheit (18° C.) before the print is transferred, and in the case of a very rough paper it is well to give it five minutes in water at about 140° Fahrenheit (60° C.) just before use. The print should be transferred as soon as the exposure is complete, since bichromated colloids show a phe-

nomenon known as the "continuing action." That is, they keep on printing after removal from light, and this action may result in a correctly exposed piece of tissue being hopelessly over-printed four or five hours after being taken from the printing frame, even if stored in the dark. The continuing action may be retarded by keeping the print under pressure, as in a printing frame, or by storing it in a platinum tin with preservative, and may be completely arrested by washing the print for half an hour in cold running water. If the print is washed in this manner, and after drying is stored in a cool, dry place, transferring and development may be postponed for several weeks, or even months.

The transfer paper having been properly soaked (care having been taken to see that no air-bubbles adhered to it and that the coated side did not float out of the water, either of these circumstances being likely to cause blisters or tearing of the print) it is placed face down in a tray of water at about 65° Fahrenheit (18° C.). The print is taken from the frame and is placed face up in the same tray, being completely covered with water, and air-bubbles being removed. The tissue will at first tend to curl up, film side in, owing to the fact that the backing absorbs water more rapidly than the gelatine, and it must be pressed down under the surface of the water. The tissue will gradually flatten out, and if left for five or ten minutes would curl the other way. Just before it flattens out, however, the transfer

paper is turned face up and the tissue face down, the two being brought together under water, film to film. They are lifted out together, drained for two or three seconds, and laid on a piece of glass, tissue uppermost. The tissue is held in place with the fingers of one hand and the squeegee is applied, lightly at first to expel any air-bubbles which may be between them (since these would cause blisters in the finished print) and then more firmly, to expel the water and bring the two films into close contact. It is well to start slightly beyond the middle and work toward one end, afterward reversing the glass and working toward the other end, for bubbles thus have a shorter distance to travel than otherwise. Squeegeeing being finished, a sheet of blotting paper is laid over the print and the two are left under pressure for half an hour or so to insure firm cohesion of the gelatine films. The writer generally uses six or eight old 14×17 negatives to furnish the required pressure, but in the case of a very rough transfer paper it will be well to use half a dozen sheets of blotting-paper and screw the whole up in a copy-press.

STRIPPING.—It is necessary that the backing paper be stripped off in order that the hot water may reach the gelatine, and this is accomplished in the following manner: The transfer paper with the adhering tissue is taken from under pressure, bending it as little as possible, and is slid, tissue uppermost, into a tray of water at about 100° Fahrenheit (38° C.).

Air-bubbles are brushed off, and after a minute or two the pigment will probably begin to ooze out from under the edges of the tissue. Should this not occur, the temperature of the water may be raised gradually by successive additions of hot water (lifting the print from the tray while adding the hot water) with a little wait after each addition, until oozing takes place. After the pigment has oozed for a minute or two one corner of the tissue may be lifted with a finger-nail, grasped between thumb and finger, and stripped off. An even pull, without stopping, and keeping the transfer paper with the adhering print under water, are generally said to be necessary, but the writer finds that this technique, though advisable, is not imperative. The backing paper may be thrown away or may be saved for the sake of the portion of the film which remains on it, this being useful for spotting the finished print.

Development.—No suggestion of the picture will show on the transfer paper at first, the print appearing simply as a slimy, dark-colored film, with irregular patches. The transfer paper is grasped at one end and shaken back and forth under the water, when the gelatine and pigment can be seen floating off, and the picture will gradually appear. Development should continue until the picture is slightly lighter than it should be when finished, since it dries darker than it seems when wet, and if necessary the temperature of the water may be raised, since hot water will dissolve more of the gelatine than will tepid.

The tissue should be so printed that development may be completed at 110° Fahrenheit (43° C.), since a higher temperature than this is likely to cause blisters or frilling, though the writer has, in extreme cases, raised the water to 140° Fahrenheit (60° C.). Such radical treatment, however, presupposes perfect technique in preparing the transfer paper and in transferring and stripping. Should the print fail to develop satisfactorily at 120° Fahrenheit (50° C.) a small amount of alkali, *e. g.*, stronger ammonia, sodium carbonate, or sodium bicarbonate, may be added to the developing water, perhaps a teaspoonful to a quart of water, but the use of an alkali is very likely to cause blisters or frilling. Care should be taken that development continues until no irregular dark patches remain on the print, though if these are due to uneven sensitizing rather than to incomplete development it will be impossible to remove them. Most writers recommend the use of an alum bath for clearing and hardening, but hardening is not necessary unless multiple prints are to be made, and the slight amount of bichromate remaining in the film will not be perceptible unless a white transfer paper is used. However, if it is desired to clear the print, it may be given five minutes in a 5 per cent solution of powdered alum, being afterward rinsed in three or four changes of cold water and hung up to dry. A 5 per cent solution of sodium bisulfite or of potassium metabisulfite is more effective than alum in removing the bichro-

mate stain, though these do not harden the gelatine. Whether the clearing bath is used or not the print should be rinsed.

Local Modifications.—Should portions of the print be too dark for the desired pictorial effect they may be raised in value while in the developing water by brushing lightly with a tuft of cotton or a camel-hair or sable brush, or by directing a stream of hot water on them, but this work should be done gently and cautiously or the film may be torn, this being especially likely to happen if development has been forced by means of an alkali. Local values may be raised in the dry print by means of a hard pencil eraser. Should it be desired to darken an area, this is best done on the dry print by softening a little piece of unexposed tissue in warm water and applying the softened gelatine and pigment to the print with a brush, this method being especially useful for spotting.

Multiple Printing.—In multiple printing a single print is made in the usual manner and hardened, and a second or even third or fourth print is superposed on it. The second print may, of course, be either in the same tissue as the first or in a different one, and may be either lighter or darker than the first print, or of the same quality. There is practically no limit to the number of printings that may be given, the writer having superposed five printings of Ivory Black on one of Red Chalk, to get a special effect. If different colors are used, care should be

taken to avoid such as are complementary, since the combination of these will give black. Thus, an attempt to print a sunset sky in red and the landscape in green will result in a warm black sky and a cool black foreground, unless, of course, each portion of the negative is shaded while the other is being printed.

Registration.—Some means must be employed to insure that the outlines of the second print coincide with those of the first, and if film negatives are used, the easiest method of registration is to cut a mask of thin, opaque pressboard, which can be bought at a stationery store. An opening slightly smaller than the negative is cut in this, and the film is fastened to it by a touch about an inch long of Duco cement at one edge. The film must not be fastened down all around, or the different coefficients of expansion of the film and the pressboard will cause buckling with changes of temperature. The advantage of Duco cement over glue is that, being transparent, it does not cause a spot on the print if a trifle of it gets on the exposed part of the negative. Registration marks like those shown in Fig. 41 are made on this mask and on the back of the several pieces of carbon tissue, which are cut to the same size; if these marks on the carbon tissues are made to coincide with the marks on the mask and on the transfer paper, the images must necessarily be in register. It is possible by this means, using reasonable care, to work to an error of not over ½ millimeter (1/50 inch) which is

plenty close enough for the ordinary pictorial photographer; if finer registration is needed, it can be secured by using a magnifying glass, but as a rule the variations in size of the transfer paper, owing to non-uniform stretching, will be at least this great. It is well to label mask, tissue, and transfer paper with the word "Top," or some similar indication, as it is very embarrassing to find, on developing the second or third printing, that it has been transferred upside down.

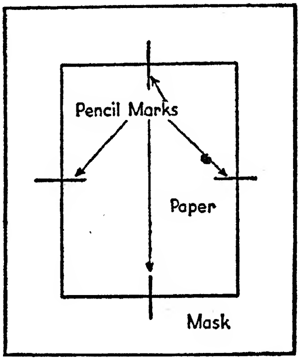


FIG. 41

If glass negatives are used, a piece of cardboard the size of the printing-frame is used, an opening being cut in this, just large enough for the negative to fit into. The cardboard should be a trifle thinner than the negative. Strips of gummed mending tape are fastened around the opening, extending 1/4 inch or so over the edges, to furnish a safe-edge, and pencil marks are made on the cardboard, as shown

in Fig. 41, these serving, as in the case of the film mask, for registration.

Obviously, however many prints are made in this manner, the outlines of the negative and the edges of the tissue will always be in the same relative position, and if steps are taken to insure placing successive pieces of tissue in the same relative positions on the transfer paper, the printings must register. Guide marks are made on the transfer paper with a fine-pointed B or 2B pencil, as shown in Figure 41, this being done after the tissue has been squeegeed to the transfer paper, and either before putting the two under pressure or just before stripping. Stripping and development proceed in the usual manner, but the finished print need not be hardened before putting to dry unless the later printings are to be developed at a higher temperature than the earlier ones. Hardening is best accomplished by soaking the print for ten minutes in

Water..........................	10 ounces	500 cc.
Formaldehyde, 40 per cent solution.	1 ounce	50 cc.

A 5 per cent chrome alum solution may be used, but the formaldehyde is preferable, since formaldehyde is an aqueous solution of a gas, which is driven off by drying, whereas chrome alum, unless thoroughly washed out of the film, may cause reticulation of the second print. The second and subsequent prints are registered with the negative exactly as the first, and in applying them to the first print this is soaked just like a new piece of trans-

fer paper, the marks on the second print being made to coincide with the pencil marks on the transfer paper before squeegeeing. It may be that the second print will swell to a size different from that of the first, or that the paper carrying the first print will not expand to its original size, and in this case the only thing to do is to register as nearly as possible, since the variation is not likely to be of importance in pictorial work. Stripping and development of the second print proceed as in the case of the first.

FAILURES.—It is not possible to give, in a book the size of the present one, a complete list of all the causes of failure that may occur in carbon work, since such a list would occupy too much space; but this fact need not deter the amateur from taking up carbon printing, many of the faults in question being unlikely to occur. Still, a few of the more usual ones may be mentioned.

Tissue which has dried too slowly or has been kept too long after drying will give degraded lights, and may refuse to adhere to the transfer paper; failure to adhere, either all over or in spots, being also due at times to insufficient soaking of the transfer paper or excessive soaking of the tissue before squeegeeing, to insufficient pressure, to an attempt to transfer to the uncoated side of the transfer paper, or to an excessively hard gelatine on the transfer paper.

Air-bubbles on either tissue or transfer paper, at any stage of the work, may cause blisters, and these

may also result from the use of water at too high a temperature or of alkali.

Frilling or tearing may be caused by the use of a tissue with old edges, by undue haste or roughness in stripping, by serious over-printing, or by the fact of the tissue overlapping the edge of the transfer paper.

Using the sensitizer below 60° Fahrenheit (16° C.) may cause reticulation of the film and if the sensitizer is above 75° Fahrenheit (24° C.) the gelatine may be softened, even, in extreme cases, melting. Hence, if the room temperature is 80° Fahrenheit (27° C.) or more, it is advisable to chill the sensitizer and the ferrotype plate.

Grease may cause blank spots on the print, or even blisters, the chief danger from this cause lying in finger marks, this circumstance furnishing an additional reason for using rubber gloves.

General Remarks.—It may be thought, from the long and apparently complicated description of the process, that carbon printing is difficult, but this is by no means the case. The writer has heard of an expert carbon printer who, starting with the sensitized tissue, finished two hundred prints in a day, this being far in excess of what any pictorial worker will wish to make.

If it is desired to have the print the right way around, and to have precise definition, double transfer may be resorted to, in which the print is first transferred to a temporary support, where it is de-

veloped, and thence retransferred to a final support. The writer, however, has never found this method to possess any advantages for pictorial work, and it unquestionably has several disadvantages, since it adds an extra process—the most delicate of all—and limits the possibilities in the matter of texture, the only surface possible in double transfer being a smooth one. Of course if an enlarged negative is to be used it may be reversed at the time of enlarging, but the diffusion resulting from printing from the back of the plate is not likely to be in excess of that desired by the pictorial worker.

SPEED AND SCALE OF CARBON TISSUES.—The various carbon tissues render widely different scales of gradation and print with different speeds. The writer has never seen any definite information bearing on these points, and feels that something of the sort would be valuable to pictorial workers, both in enabling them to adjust the printing time with, in consequence, a possible saving of material, and also in making it possible for them to select the carbon tissue which will best render the negative in question, or to make the negative to suit the tissue to be used. Of course, the selection of the tissue does not depend merely on the scale of the negative, since the color to be used for printing is of importance, but it often happens that there is a possibility of choice among several tissues.

The experimental work involved in making up the table given below was done by one of the writer's

pupils, the late W. R. Latimer, and was carried out in the following manner: A photometer of forty steps was first made by gluing as many pieces of tracing paper to a glass plate, each piece except the first having in it an opening slightly larger than the preceding one, that is, the first piece was entire, the second piece had an opening ½″ × 1″, the third an opening 1″ square, the fourth an opening 1½″×1″ and so on. Thus it will be seen that forty steps differing from one another by slight gradations resulted, and the different tissues having been sensitized and dried as nearly as possible in uniform conditions were printed in this photometer exactly as though the latter were an ordinary negative, a constant light (mercury vapor arc) being used. The printing time in each case was adjusted so that the lower gradations of the photometer were blocked up, and in no case would the tissue register the full number of steps. The steps were of course numbered in sequence, the thinnest being 1 and the densest being 40. Development in each case was in water at precisely 112° Fahrenheit (44.5° C.). The scale of the tissue was determined by the number of tints visible in the finished print, the lowest being the first to block up and the highest the last one which showed a distinct tint on the paper; that is, if 3 and 4 showed no differentiation but 4 and 5 did, four was considered to be the extreme dark of the tissue. This table does not show any relation between the printing speed of the tissue and the printing speed of

P. O. P., since, as noted above, the latter varies considerably in speed. Ivory Black was found to be the most rapid printing tissue, and the speeds of the other tissues are indicated in relation to this. That is, if a certain negative requires one minute exposure to print in Ivory Black, it will need one and one-quarter minutes to print in Warm Black. These speeds are approximate only.

Tissue	Relative Speed	Scale
Ivory Black	1	15
Blue Black	1	15
Warm Black	1¼	15
Neutral Ink	1¼	13
Brownish Black	2½	16
Platino Black	1¼	16
Standard Brown	2	16
Vandyke Brown	1¾	18
Portrait Brown	2¼	19
Ruby Brown	1¾	17
Chocolate Brown	3	15
Cold Bistre	1¼	18
Green Sepia	1¾	19
Rembrandt Sepia	1¼	18
Cool Sepia	2¼	16
Sepia	1¼	17
Turner Sepia	2	19
Italian Green	1¼	18
Gray Green	2½	15
Terra Cotta	3¼	18
Bright Mauve	1½	13

CHAPTER XII

Technique of Carbro

Some years ago there was placed on the market a process known as ozobrome, which afforded a means for making true carbon prints from bromide or gaslight prints, without the use of daylight. This process, however, was never commercially successful, partly because of the difficulty of obtaining supplies, partly because of lack of general interest, and partly because no sensitizing formulæ were published, the worker being obliged to purchase his sensitizer ready prepared. For these reasons it was withdrawn after a time, but the method has been revived under the name of carbro, complete formulæ being published, and the process offers so many advantages over carbon that it seems well worthy of attention.

Briefly, a sheet of carbon tissue is sensitized by being immersed for a time in the proper solution, and is then squeegeed to a bromide print. After remaining for a few minutes, it is stripped and squeegeed to a sheet of single transfer paper, the subsequent proceedings—stripping, development, clearing and drying—being the same as in ordinary carbon work. The printing, that is, the partial insolubilization of the gelatine, results from the chemical

reaction between the sensitizer and the silver of the bromide paper image, exactly as in regular carbon work it results from the reaction between the sensitizer and light.

It will be seen that this method avoids the necessity for sunlight for printing; all operations may be carried out either by artificial light or by daylight, since the carbon tissue is at no point sensitive to light. Also, it makes possible the production of large carbon prints without the need for an enlarged negative, thus eliminating the most delicate item in the making of large prints. Further, as will be seen later, the process is much more flexible than ordinary carbon, far greater variations of total contrast than are possible with carbon being attained with the utmost ease.

THE BROMIDE PRINT.—It will be found that the same difficulty exists here as in using a fixed-out bromide or chlorobromide paper as a transfer paper in carbon printing; namely, that the super-coating of hardened gelatine interferes materially with the functioning of the process. If we are using the non-transfer method, in which the print is not transferred to another sheet of paper but is developed directly on the bromide print, the gelatine of the tissue will refuse to adhere to the hardened super-coating, and frilling or tearing of the gelatine will result. If, on the other hand, the transfer method is employed, the chemical reaction on which the process depends will take place to some extent within the super-coat-

ing instead of in the pigmented gelatine, and the final carbro print will lack detail and gradation in the lights. It is therefore necessary to use a bromide or chlorobromide paper which does not have this super-coating, as explained in the chapter on carbon printing. In his book, Colour Photography In Practice, D. A. Spencer states that chloride and chlorobromide papers will not work for three-color carbro, but that it is imperative to use a bromide paper. Certainly the present writer's own experience indicates that for ordinary black-and-white carbro the English bromide papers, particularly that made by Illingworth especially for carbro work, are decidedly preferable to any American-made paper. Any surface may be used, though the matt surfaces are somewhat easier to handle than the glossy or the semi-matt.

Since carbro, like carbon, tends to give slightly degraded lights, it is desirable that the silver print be a trifle higher in key, so far as the lights are concerned, than the finished carbon is to be, and it is imperative that it receive full development; as in sepia toning, if the light-affected silver has not been completely reduced uneven results may be expected. This means that the bromide print should have the minimum exposure which will render full detail in the lights, and that it should remain in the developer for two or three minutes after all action has apparently ceased. It is desirable that the bromide be

printed with a white margin, to act as a safe-edge, but this is not strictly necessary; the same result may be secured by cutting the carbon tissue a trifle larger than the bromide print, and allowing the support on which squeegeeing is done to serve the purpose of a safe-edge.

There are two methods of working, the transfer and the non-transfer. The former presents the advantages of offering a greater choice of final support, since any single transfer paper which is suitable for ordinary carbon work may be used, whereas in non-transfer the final support is the bromide print; and of enabling the worker to produce several carbons from one bromide. The non-transfer offers the advantages of eliminating one operation, thus simplifying the process somewhat; and of rendering multiple printing much easier. We will first consider the non-transfer method.

Non-Transfer Method.—Two solutions will be required, a sensitizer, which reacts with the silver of the bromide print to insolubilize the gelatine of the carbon tissue; and a control bath, which governs the action of the sensitizer, to produce the desired quality in the finished print. They are made up thus:

A	Water	32	ounces	1000	cc.
	Potassium ferricyanide	700	grains	48	grams
	Potassium bichromate	700	grains	48	grams
	Potassium bromide	700	grains	48	grams

Sensitizing bath:

Water	18	ounces	525	cc.
A solution	6	ounces	175	cc.

This keeps well, and may be used repeatedly.

B	Acetic acid glacial........	2	drams	7.5	cc.
	Hydrochloric acid C P....	2	drams	7.5	cc.
	Formaldehyde 40%.......	5½	ounces	160.0	cc.
	Water...................	3	drams	11.5	cc.

Control bath:

Water....................	32	ounces	1000	cc.
B solution...............	1	ounce	30	cc.

This will serve for about ten 8×10 prints, and should then be thrown away.

A suitable bromide print having been secured, it is soaked in water at 60° to 65°F. (15° to 18°C.) for fifteen or twenty minutes, care being taken to avoid air-bubbles. It is then laid face up on a horizontal sheet of glass, given two or three light strokes of the squeegee to make it adhere to the glass, and an ounce or so of water is poured on it and spread over the surface. The carbon tissue is then immersed in the sensitizer for three minutes, in the same manner as in carbon printing, is drained for fifteen seconds, and is then immersed, face up, in the control bath for the required time, the tray being constantly rocked.

The quality of the finished print depends intimately on the time in the control bath, long immersion giving soft, high-keyed prints, and brief immersion giving darker ones of more contrast. It will be seen that the time of immersion depends on the quality of the bromide print, the tissue used, and the result desired, but a fair general average for the first trial will be twenty seconds. As an example of

the variation possible, the writer has made a normal print, excellently graded and detailed, from an excessively strong bromide print in which the shadows were practically blocked up; Standard Brown (a soft-working tissue) was used, the time in the control bath being ten seconds. Another print in the same tissue was made, giving ninety seconds in the control bath, and the result was a mere ghost of a print, though fully detailed and graded in both lights and shadows. There must of course be some limit to the control possible by this method, but it would appear to lie far beyond anything that may be needed in practice.

The tissue having had the proper time in the control bath, it is lifted out and without draining is laid face down on the bromide print and squeegeed into contact with it exactly as a carbon print is squeegeed to the transfer paper. So long as there is a good film of water between the two gelatine surfaces the carbon tissue may be slid around more or less, with little risk of damage, but as soon as the two come into contact any slipping will cause blurring of the outlines in the finished print, or even a double image. It is therefore desirable to hold the carbon tissue firmly in place while squeegeeing.

The carbon tissue having been squeegeed on the bromide print, the two are placed under moderate pressure for about twenty minutes. Some workers prefer to put the prints between waxed paper while they are under pressure, claiming that they should

not be permitted to dry out, whereas others say that a moderate amount of drying promotes cohesion of the gelatine, and therefore use blotters. This seems to be largely a matter of personal choice; so far as the writer can see, the chief difference is that drying results in a somewhat darker carbro, requiring the use of slightly warmer water in developing.

When the bromide, with its adhering carbon tissue, has been under pressure for the required time, the two are lifted from the glass and slid into tepid water, when stripping and development proceed as in carbon printing, except that a carbro print usually develops at a slightly lower temperature than a carbon.

Further Treatment of the Silver Print.—It will be found that the action of the sensitizer has caused bleaching of the silver image, and any one of four courses may now be taken. (a) The silver image may be entirely removed with Farmer's reducer, leaving a pure carbon print. (b) The silver image may be redeveloped to a sepia, using barium sulfide, as described on page 172, thus giving the effect of a multiple print. (c) The image may be redeveloped to a black with any ordinary developer, and kept thus. (d) The image may be redeveloped to a black as in (c), and made the basis for multiple printing.

It may be found that the bleaching has not been complete, some traces of the black image remaining in the shadows, and if (b) is decided on, the bleaching

should be completed with the ferricyanide and bromide solution before toning. If redevelopment to black is decided on, the print should be immersed for at least fifteen minutes in the developer to insure thorough blackening. Any developer may be used, but amidol is preferred, since this, working without alkali, does not tend to soften the gelatine. If multiple printing is to be carried out, the print should be dried, thus hardening the gelatine, and resoaked for subsequent printings. Obviously, in this method no registration is necessary; the sensitized carbon tissue is simply squeegeed in place as in the first instance, and the silver image takes care of registration. There does not seem to be any practical limit to the number of printings which can be applied in this manner, but with some papers it may be necessary to harden the gelatine between printings; for this purpose formaldehyde is recommended, as on page 231. If an alkaline developer is employed for redevelopment of the bromide, it must be thoroughly washed out of the print, or frilling of the subsequent carbons may result.

Transfer.—In the transfer method the carbon tissue is sensitized and squeegeed to the bromide exactly as before. After the two have remained in contact for the proper length of time the carbon tissue is simply stripped, dry, from the bromide, and is then squeegeed to a previously soaked piece of single transfer paper and placed under pressure as in ordinary carbon work. The subsequent operations

of stripping and development are carried out in the same manner as with regular carbon. If multiple printing is to be resorted to, registration is necessary, and this may be effected very readily by making pencil marks at the edges of the carbon tissue as it lies on the bromide print (which should, obviously, be cut larger than the carbon tissue) and also on the transfer paper, after the carbon tissue is squeegeed thereto. By cutting all subsequent pieces of tissue to the same size and registering them with both sets of pencil marks registration of the several images will be insured.

FAILURES.—Aside from the failures possible in ordinary carbon work, there are a few which are peculiar to carbro, and these may be briefly mentioned.

The final result depends to some extent on the temperature at which the sensitizing is done, an excessively low temperature giving weak prints, whereas too high a temperature causes over-printing of the carbon image. The solutions should be maintained between 60° and 65°F. (15° and 18°C.).

Insufficient pressure in squeegeeing may cause weak and flat finished prints; on the other hand, too heavy squeegeeing may cause the carbon tissue to tear during stripping.

In localities where the tap water contains a large amount of lime salts, carbro prints made with this water will show weak or even totally blank highlights. In such places the sensitizer and control bath should be made up with distilled water, and the

unnecessary. The practical limit, due to mechanical causes, appears to be about six carbons from one bromide, though with care this may be increased slightly.

General Remarks.—It will be seen that the carbro process affords an opportunity for the production of prints and enlargements of the highest pictorial quality, without certain of the restrictions hitherto placed on the worker by the limitations of carbon, and the author feels that the process is well worthy the attention of both the ambitious amateur and the professional who aims at finer results than those given by the general run of printing papers.

CHAPTER XIII

Technique of Fresson

THEORY.—Fresson is to all intents and purposes the Artigue process, which enjoyed more or less popularity twenty-five or thirty years ago, revived under a new name and with certain improvements.

A sheet of smooth or very slightly rough paper which will withstand moderately harsh treatment is first given a coat of hardened gelatine, and over this is placed a coat of some colloid—probably gelatine —which is so treated as to melt at 96°F. (35°C.). With this second coat of gelatine there has been incorporated a relatively large amount of some earth pigment, the result being to make the coating opaque and at the same time to give a matt surface that is entirely devoid of lustre. The paper is sold insensitive (in which condition it will keep for years if stored in a cool, dry place) and is sensitized by immersion in a solution of potassium bichromate, dried in the dark, and printed. As with carbon and gum, the effect of printing is to render the pigmented colloid more or less insoluble, depending on the amount of light-action. The print is then soaked until limp in cold water, and is placed for one minute in water from 88°F. to 96°F. (31°C. to 35.5°C.) depending

on the effect desired. It is then taken from the water and placed on a smooth slanting surface, and a purée of boxwood sawdust and water is poured repeatedly over it, this soup gradually eroding and carrying off the soluble portions of the gelatine, with the pigment which they contain, thus bringing out the gradations of the subject. Although it might be expected that this development with sawdust would give a grainy texture to the print, such is not necessarily the case; it can be made to do so, but a Fresson print on smooth paper, properly handled, has a texture nearly as fine as a palladium print—so fine as to be, to the naked eye, equal to the metallic image. Although useful for broad effects, Fresson is even more delightful when employed for small prints, since these, being examined at close range, show more clearly the medium's admirable rendering of the delicate gradations of the negative.

Materials Required.—The necessary materials are very simple: Fresson paper, a supply of P. O. P., potassium bichromate, a thermometer, a supply of boxwood sawdust (obtained with the paper), a sheet of glass or metal slightly larger than the paper, a cup for pouring the sawdust soup. These, with the trays, graduates, and printing-frames ordinarily found in a photographer's workroom, are sufficient, though if much work is to be done, it is convenient to have a device such as that shown in Fig. 42. This consists of a zinc trough containing the sawdust soup, and a zinc plate on which to rest the Fresson print during

development. The edges of this plate are slightly bent up, to keep the soup from running off at the sides, and it rests freely on the support, so that the angle of flow may be changed by moving the support nearer to or farther from the trough. This piece of apparatus was designed and built, and presented to the writer, by Mr. William G. Houskeeper.

SENSITIZING.—This is done by immersion, as with carbon tissue, the standard solution being

Water	32 ounces	1000 cc.
Potassium bichromate	155 grains	10 grams

This is a 1% solution, but the sensitizer may be used either stronger or weaker, as will be explained later: if used stronger than 5%, however, it will cause the pigmented colloid to strip or to break down in the lights, and even 5% is dangerously strong.

The surface of the paper is very delicate and susceptible of abrasion or finger-marks, even when dry, so it should be handled entirely by the edges. It is well, for this reason, and also for convenience in developing, to use paper a size larger than the negative, say 10×12 or 11×14 for an 8×10 film, and to print with a mask, so as to get an unprinted margin at least half an inch wide all around the print. The paper can be bought in 8×10, 11×14, or in sheets 23½×39, in eight or nine different colors and four different supports, and it is the writer's practice to sensitize 8×10 sheets and cut them in two (not four) when printing from 4×5 negatives.

The sensitizer should preferably be used between

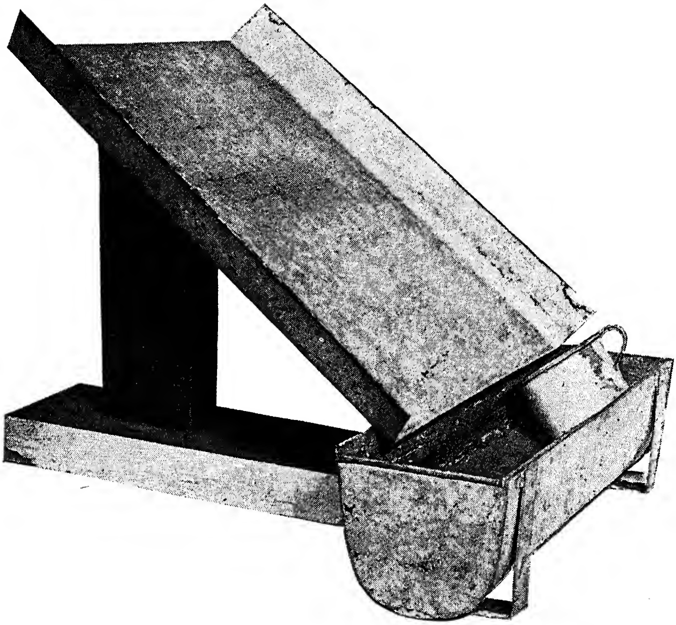


FIG. 42.—APPARATUS FOR FRESSON DEVELOPMENT

60°F. and 65°F. (15.5°C. to 18.5°C.) but it may be allowed to go as high as 72°F. (22°C.) with careful handling. An inch or so of the solution being placed in a tray, the paper is slid into it, one sheet at a time, face up, held down until it ceases to curl, any air-bubbles which appear are broken (using an extremely delicate touch) and the tray is rocked constantly. At the expiration of four minutes the paper is lifted out and hung up in the dark, by means of clips, to dry. It is well to hang it so that it drains from one corner, since a line of sensitizer, collecting along one edge, may extend by capillary attraction into the printing area and cause excessive sensitiveness in some portions of the paper. Drying is less rapid than with palladium, but much more so than with carbon, and may be hastened by means of an electric fan; artificial heat cannot be used, nor can the paper be dried on glass or on a ferrotype plate, as is done with carbon. Sensitizing may be done in an ordinary room, as the paper is not sensitive until dry.

PRINTING.—Printing should take place as soon as the paper is dry (sensitized Fresson deteriorates even more rapidly than does carbon) and sunlight or a strong artificial light is necessary. It must be done by time, since there is no visible image in the darker papers, nor is the image definite enough, even in the lighter colors, to serve as a reliable guide. It is the writer's practice to make a proof on P. O. P., and, for normal results, to print a black or brown-black Fresson half or three-quarters (usually half) the time

required for the silver proof. For special effects, this time may be varied, as will be explained later, and it will be found that a blue or green paper prints somewhat faster than this, a brown or red somewhat more slowly. Fortunately, there is considerable latitude in the printing time of Fresson—more, in fact, than with any other medium except gum.

Development.—The print is taken from the frame and slid, face up, into a tray of water at about 65°F. (18.5°C.) where it is rocked for four minutes. It is then drained and placed for *one minute* in water at exactly 88°F. (31°C.). After one minute it is taken from the water and laid face up on the slanting support, and development begins. The angle of the support is far from critical, though if delicacy of gradation rather than a coarse texture is desired, a low angle—say, 25° to 30° with the horizontal—is better than a steeper one.

The package of boxwood sawdust has previously been well mixed with water, the amount of water being by no means critical; the mixture should be somewhat slushy, yet thin enough to run rather freely off the print, and for delicacy of gradation a thin mixture is better than a thick one.

This soup is taken up in any convenient cup or graduate, and is poured gently and repeatedly over the print, being allowed to run off as it will; after five minutes or so, the highlights and the unprinted margin should begin to show, and if it is desired to inspect the progress of the work, the sawdust is al-

lowed to settle for a few moments, the clear water then being skimmed off and used to rinse the print. If the printing time and the temperature of the soaking water have been correct, the print will gradually appear and will develop to the proper point, when it is rinsed in cool water to remove any adhering particles of sawdust and is hung up to dry, the operation then being complete. There may remain a slight residual color from the sensitizer, which can be removed from the dry print by an alum bath as in the case of carbon, followed by rinsing and drying.

The print will develop to a reasonably definite point, depending on the relation between depth of printing and the temperature of the soaking water; beyond this point continued development has little or no effect. If the print does not develop to the proper point with twenty to thirty minutes of the soup treatment, it may be placed for one minute in water at 90°F. to 92°F. (32°C. to 33°C.) after which the soup-pouring is resumed. If it remains stubborn, still warmer water may be used, but the limit (except in the case of very old paper, or paper which has been kept for some time after sensitizing) is 96°F. (35.5°C.); above this, the pigmented gelatine will either wash off entirely in the water or else tear off in pieces under the sawdust.

Some workers use warmer water to start with, and pour the soup on the print with considerable violence, thus shortening the time of development considerably; the writer has seen an 11×14 print de-

veloped in ten minutes with this technique. But this tends to give a coarse, granular texture, and though such an effect may be desirable in some cases, one of the beauties of Fresson lies in its exquisitely delicate gradations, so the writer prefers to work more slowly and gently, often spending an hour or more on the development of an 8×10, or of two 4×5's, which latter can easily be developed simultaneously, side by side.

Development should continue until the print is decidedly lighter than it is to be when finished, since Fresson dries considerably darker than it seems while wet, this darkening being much more apparent in the lower than in the higher tones. If the print is too dark when dry, it may be soaked again in the cool water, followed by warm, and given further development with the sawdust soup. The finest texture and gradation are obtained when the printing time is kept down to a minimum, the soaking water is correspondingly cool, and development is slow and gentle.

Local Modifications.—There is great opportunity for local modifications, Fresson being extremely flexible in this respect. Areas may be left dark by turning the print so that the sawdust soup does not run over them, or may be lightened by pouring a stream of the soup directly on them; also, pouring the soup in a stream or in drops from a height will force development. Fine areas can be brought up in value by means of a soft camel-hair brush, though

this latter technique must be used with caution, and preferably with the print below the surface in a tray of cool water, to avoid scratches and brush marks. Still, with a soft brush and a delicate touch the work can be done out of water, when the effect is much greater than in the former case.

Variations of Contrast.—There are several ways in which the total contrast can be varied.

(1) A weak sensitizer gives slower printing and greater contrast, a stronger one giving quicker printing and softer prints, the limit in this direction being, as already stated, 5%. The printing time is almost exactly inversely proportional to the concentration of the sensitizer: that is, with ½ of 1% it is twice as long as with 1%, and with 2%, half as long.

(2) Over-printing, with the use of a warmer soaking water (up to 96°F. or 35.5°C.) gives decided increase in contrast. This, of course, may be used in conjunction with variations in the strength of the sensitizer.

(3) An extreme technique, which is certain to produce a coarse, granular texture, is to print for two or three times the normal printing time, soak the print for four minutes in cool water, as usual, then immerse it for fifteen or twenty seconds in water at about 100°F. (38°C.) and develop as usual. This will give a very marked increase of contrast, but is not recommended for prints smaller than 11×14—nor, in fact, even for that size, if really fine photographic quality is desired.

SPOTTING.—This is best accomplished by taking a small scrap of unsensitized Fresson paper, softening the emulsion in water at 96°F. (35.5°C.) and applying this pigmented colloid to the print with a soft, fine-pointed brush. However, for small spots an ordinary carbon spotting pencil, sharpened to a needle point, may be used provided the spotting is done by stippling rather than by stroking.

GENERAL REMARKS.—There is no apparent limit to the keeping qualities of the sawdust, though if much work is being done, so that the mixture of sawdust and the colloid which is washed from the prints remains moist, this mixture may sour. In such a case, the addition of a few grains of mercuric chloride will act as a preservative: formaldehyde or carbolic acid must not be used. Still, the writer has kept the sawdust in a moist condition for weeks at a time, with no indication of souring. If the sawdust dries out, the colloid will form a hard crust on the surface, but this softens up on the addition of water, and may be disregarded.

A technique which is used by some workers is to give gross over-exposure, and to soak the print in a weak solution of Javelle water instead of in plain warm water, before development. The writer does not care for this method, since the results are invariably coarse in texture and lacking in gradation, the peculiar beauty of the medium being sacrificed with no compensating gain.

CHAPTER XIV

Technique of Gum

THEORY.—The theory of gum printing is the same as that of carbon in so far as it depends on the insolubilization of a bichromate-sensitized, pigmented colloid film by the action of light, but varies from it in one important respect. In both cases the image consists of varying thicknesses of pigment-bearing colloid, but in gum work the variations of thickness are due to the fact that the paper support is rough, so that, if the film has approximately a uniform surface, the insoluble colloid extends varying distances down the sides of the little projections on the surface of the paper, the varying thickness of the film resulting from this irregularity in the surface. An interesting consequence follows from this, namely, that if a smooth gum coating is spread on a perfectly smooth surface, such as glass, no half-tones can be obtained on printing, merely a silhouette resulting, but if the gum coating is stippled a print with half-tones may be made, though the scale will be limited. It follows, also, that a rough paper will give a longer scale of gradation than a smooth, this fact being of importance to the gum printer.

In practice gum differs from carbon in that the

colloid used is gum arabic instead of gelatine, that cold water instead of hot is (normally) used for development, that development takes place not from the back of the film but from the front, the soluble colloid seeping out through the pores of the overlying insoluble layer, and that the paper cannot be bought ready prepared, but must be coated by the user.

MATERIALS REQUIRED.—The materials necessary for gum work are paper, gum arabic, a bichromate salt, pigment, and two brushes, one for spreading and one for blending. These will be considered in the order given.

Many different papers are available, the two requisites being that the stock shall be such as to stand prolonged soaking in water, and that it shall be fairly well sized. Any good drawing or charcoal paper, such as Strathmore, Lalanne, Michallet, or Whatman, may be used, as well as many other drawing papers, but some will need resizing if multiple prints are to be made.

It is best to procure the highest grade of gum arabic, and to obtain it in the granular form, rather than either the lumps or the powdered, since this is the easiest to dissolve. The solution consists of

Water	32 ounces	1000 cc.
Gum arabic	1 pound	500 grams
Mercuric chloride	90 grains	6 grams

The easiest way to dissolve the gum is to rub it up, a little at a time, with water in a mortar. The mercuric chloride is added toward the end of the opera-

tion, being dissolved in part of the water and stirred thoroughly into the entire gum solution, which is then strained through two thicknesses of cheesecloth and stored in an air-tight bottle. The function of the mercuric chloride is to act as a preservative, for, although a sour gum solution works quite as well as a fresh, it works differently, and will not be dependable for constant results. This gum solution will keep for a long time; the writer has had such a solution remain in perfect working condition for seventeen years.

The sensitizer may be bichromate of either potassium, ammonium, or sodium, the first being usually recommended. The writer prefers the last-named, since it may be made up in a much more concentrated solution, giving a quicker printing film. The cost per pound of the salt is practically the same. If the potassium salt is used the sensitizer is

Water, hot..................	30 ounces	1000 cc.
Potassium bichromate.......	1440 grains	100 grams

If sodium bichromate is used the formula is

Water, warm..................	32 ounces	1000 cc.
Sodium bichromate...........	2 pounds	960 grams

The sensitizer keeps indefinitely.

The pigments may either be dry powders or in water-color tubes, the writer preferring the latter, since the dry powders require grinding, this being a laborious and dirty process. Oil colors cannot be used successfully. The water-colors may be those of

any good maker, such as Talens & Son, Winsor & Newton, or Devoe, but it is best to adhere to those of one maker, since the different makes vary somewhat.

The fundamental color most used is black, and positive colors such as red, green, and blue are, generally speaking, to be avoided for esthetic reasons. It is, however, desirable at times to modify the black somewhat in order to obtain cold or warm blacks or browns, and the following pigments will be found useful:

Lamp Black, a strong color having a slight greenish tinge.

Ivory Black, a much weaker color, but pure.

Rembrandt Black, a strong pure color manufactured by Talens & Son.

Burnt Umber, a weak brown, very useful for modifying blacks.

Burnt Sienna, similar to Burnt Umber, but reddish in hue.

Prussian Blue, a strong, slightly greenish color.

Cobalt Blue, weaker than Prussian blue, but pure.

Cadmium Orange, a strong pure color.

Some workers advise other colors in addition to those enumerated, but the writer finds that the ones named will do practically everything that is desired except in very special circumstances.

The spreading brush should be of moderately stiff bristles, though if it is too stiff the paper may be injured. A good width of brush for any size of

print up to 20″×24″ is three inches. The blending brush is the type known as a "flat badger blender," and should preferably be about four inches wide, since a smaller one will not work satisfactorily with large prints. After some skill has been acquired it will be found possible to blend perfectly on rough papers with the spreader, but the blender is always useful. The use of these brushes is not, however, imperative, since practice will enable the worker to spread and blend with any kind of brush that is not too stiff. The blender is expensive to buy, but lasts indefinitely; the writer has used the same one for nearly thirty years.

SIZING.—With good drawing papers it will not be necessary to size even if multiple prints are to be made, but some stocks are so porous that unless sized they will absorb the pigment unduly. The size may be either temporary or permanent, the former being the easier to apply if only single prints are to be made, but it possesses the disadvantage that it must be applied before each coating of the paper, thus introducing additional operations, whereas if the paper is permanently sized one application is sufficient, no matter how many printings are given. The temporary sizing consists of a moderately thick boiled starch paste which is applied to the paper by means of a damp sponge and well rubbed in. For permanent sizing the formula is the same as that given on page 221 for carbon transfer paper, one

application, or at most two, being sufficient to produce the desired result.

It is also possible, and often convenient, to size the paper permanently by applying a sensitized gum coating, exposing this fully to light, and then washing the sensitizer out and drying the paper before giving it the first gum-pigment coating, thus leaving a coat of insoluble gum on the surface. This method is particularly useful when it is desired to give a little tone to the lights, as in the case of portraits or sunny landscapes. The writer finds a good mixture for either portraits or landscapes to be

Gum solution	3 drams	10 cc.
Sensitizer	12 drams	40 cc.
Cadmium yellow	1/8 inch	3 mm.
Cadmium orange	1/8 inch	3 mm.
Cobalt blue, a faint trace		

THE COATING MIXTURE.—The coating mixture consists of gum solution, sensitizer and pigment, and is capable of infinite variations, though a few general rules may be given:

(1) Increasing the proportion of gum increases contrast.

(2) Increasing the amount of size in the paper increases contrast.

(3) Increasing the proportion of pigment decreases contrast and gives a longer scale of gradation.

(4) Excess of pigment will stain the paper and produce degraded lights.

(5) Increasing the proportion of sensitizer renders the mixture easier to spread and blend, but gives a thinner film.

For every paper and every pigment there is a certain relationship between the amount of gum and the amount of pigment which will give the longest scale of gradation without staining the paper. This relationship is of great importance and may be determined as follows. Take a definite amount of the pigment (say one inch squeezed from a water color tube) and to it add ½ dram of the gum solution. Dipping a fine brush into this mixture, which should have been thoroughly stirred, make a mark on a piece of the paper under investigation. Opposite this mark write in pencil "1 inch to ½ dram"; add another ½ dram of the gum solution, stir thoroughly and make another mark labeling this "1 inch to 1 dram"; add another ½ dram of the gum and proceed in the same manner, continuing the additions of gum until the proportion of pigment to gum is about 1 inch to 2 ounces. It will be observed that no sensitizer is used in this test. Allow the gum to dry thoroughly on the paper and then float the latter, gum side down, for one hour in water at room temperature, without agitation. At the end of this time examine the paper and it will be found that some of the marks have disappeared entirely, some are faintly visible and others are very distinct; thus it may be found that the highest visible mark is opposite the pencil label "1 inch to 8 drams." Then if the gum pigment mixture be made up in the proportions of 1 inch of pigment to 8 drams of gum the lights in the resulting print will be faintly degraded,

the amount of degradation being probably so slight as to be immaterial in single printing, though it will of course become apparent if multiple prints are made, and in this case it will be necessary to take 8½ drams of gum to 1 inch of pigment if clear lights are desired. A note having been made of the proper proportion of gum to pigment necessary for obtaining clear lights in automatic development, a soft camel-hair or sable brush may be rubbed over the test paper, when it will be found that still others of the marks disappear, the highest remaining after this treatment being perhaps opposite the label "1 inch to 4½ drams." This indicates that if 5 drams of gum be used to 1 inch of pigment, clear lights will be obtained by the use of a brush or atomizer on the print during development. This test must be made for each paper and each pigment to be used, since some papers stain more readily than others and some pigments have far greater tendency to stain than is the case with others. If two pigments are to be mixed the amount of gum to be used follows naturally from the above test; thus if we say that it is necessary to use 4 drams of gum per inch of Ivory Black and 6 drams per inch of Burnt Umber, then if 1 inch of Ivory Black and 1 inch of Burnt Umber are mixed in order to obtain a brown it will of course be necessary to use 10 drams of gum. In general the transparent pigments such as Burnt Umber and Burnt Sienna have a greater tendency to stain than the more opaque ones such as the blacks.

Inasmuch as the proportions of the coating mixture vary with the pigment used, with the paper on which the print is to be made, and with the result desired, every worker must determine for himself what mixture he will use in a given case, and although numerous formulæ could be given, to do so would occupy an excessive amount of space and would serve no useful purpose, since it is obviously impossible to cover all conditions. Therefore but one formula for the coating mixture will be given and the worker will be left to make his own application of the fundamental principles stated above. This formula the writer has found to work satisfactorily with Strathmore Detail paper:

Gum solution....................	6 drams	20 cc.
Sensitizer........................	11 drams	40 cc.
Rembrandt Black.................	1 inch	25 mm.
Burnt Umber.....................	1 inch	25 mm.

This gives a good warm brown and does not stain the paper.

Coating the Paper.—The paper to be coated is pinned by the four corners to a smooth horizontal board, the pigment is put into a mortar or saucer and the gum solution added a little at a time, rubbing thoroughly with the pestle or with the spreading brush until the gum and pigment have been completely mixed. The sensitizer is then added and the whole thoroughly stirred. The bristle brush is dipped into the mixture and is brushed rapidly back and forth across the paper, which, as in the case of platinum sensitizing, should be rather larger than

the print is to be. It will probably be found that the paper will stretch when the mixture is applied to it and the slack should be taken up by shifting the pins, glass or metal push-pins being recommended, since they are easier to manipulate than the ordinary type. The mixture having been spread as evenly as possible with the coating brush, the blender is then taken up and the streaks left in coating are smoothed out with it. Experience only can indicate the amount of mixture to be applied to the paper, for if too little is put on it will be impossible to cover the paper completely, whereas if too much is applied the film will be so thick that it will flake in developing. The rougher the paper the more of the coating mixture it will take, but no definite indication can be given. The use of the blender requires considerable manipulative skill, which also can be obtained only through experience. The blender should be held as nearly vertical as possible and should not press heavily on the paper, only the tips of the hairs touching, and should be moved rapidly up and down and crosswise of the sheet until the coating is uniform and for a little time thereafter. If blending is stopped too soon the mixture will run together in little puddles and will give spotty prints, whereas if it is continued too long, that is after the mixture grows tacky, the hairs of the brush will cause streaks which may show in the finished print. A slight streakiness will disappear during the operations of drying the coated paper and developing the

print, and it is sometimes possible to remove brush marks by stippling the print all over with the blender, though this gives a somewhat different texture in the final result. Generally speaking, blending should not occupy more than about thirty seconds, though with rough paper it may take longer.

The operations of preparing and applying the coating mixture may be carried out in an ordinary room since, as in the case of carbon, the paper is not sensitive until dry, but drying should take place in the dark and in ordinary circumstances will not occupy over an hour, though it may profitably be hastened with an electric fan, and may, if necessary, be completed over a gas or an electric stove. If several sheets of paper have been coated the blender will be clogged with the mixture and will refuse to work properly, when it may be cleaned by rinsing under the faucet and spinning the handle between the hands.

If the gum-pigment mixture is too thick it will set before it can be blended satisfactorily, whereas if it is too thin it will take an excessively long time to blend.

Some papers, especially thin ones, buckle so when wet that it will be impossible to blend the mixture properly. If this is found to be the case the trouble may be avoided by soaking the paper until it is limp, surface-drying between blotters and coating while it is still damp. However, if this is done there will be a greater tendency for the pigment to stain the paper

than if the latter is coated dry, and allowance must be made for this fact when preparing the coating mixture.

The mistake most commonly made by beginners is in applying too heavy a coating. The tyro generally tries to get enough of the gum-pigment mixture on the paper to look black, but this is a certain guarantee of failure; the coated paper, when hung up to dry, should not be darker than a medium greenish-gray.

PRINTING.—It is quite as impossible to give definite rules for printing as it is to give definite rules for the coating mixture, since the printing speed of the paper depends on the proportion of gum and sensitizer, on the proportion and color of pigment, and of course on the quality of the light and of the negative. Obviously the greater the proportion of sensitizer and the less the proportion of pigment the more rapid the paper will be, but the color of the pigment also exerts a marked influence, pigments of non-actinic color of course printing more slowly than the blues and greens. Generally speaking, blue will print most rapidly, black next and then brown and red in the order given. With the coating mixture given above the printing time will be roughly that of platinum, provided the potassium bichromate sensitizer is employed, though if the sodium bichromate sensitizer is used the printing time will be about one-fourth of this, say from 1½ to 3 minutes in unobstructed July sunlight, using an average

negative. It is possible to make an actinometer which will enable the worker to print accurately, but the writer prefers to rely on experience and on the use of test slips, printing by time, since this is generally easier than the other method. Satisfactory test slips may be made by sensitizing plain paper, as was suggested for carbon printing.

Development.—The print should be developed as soon as taken from the frame, for the continuing action of light is the same with gum as with carbon, and to effect this the print is slid into a tray of water at room temperature, allowed to remain until limp, the water being changed two or three times if convenient, and is then turned face down, care being taken to see that no air-bubbles adhere to either the front or back, since if this occurs dark spots are likely to result in the finished picture. The proper way to avoid air-bubbles in turning the print face down is to lift it by both ends, bending it in the form of a "U," and to lower it gently until the middle touches the water. The ends can then be lowered gradually and any loose air-bubbles will run out from under the paper as this is brought down to the surface of the water. Development may be either automatic or forced, the former consisting simply in allowing the print to remain face down in the tray until all of the soluble gum has floated off, raising the temperature of the water if this proves necessary. The high-lights of the picture or the edges where the print is protected from light by the rebate of the

printing frame should appear in ten minutes or less and development should be complete in from one-half to one hour. If less time than this is required for the picture to appear as it should when finished, the print is probably under-exposed and the gum and pigment will run in drying. If the under-printing is not serious the print may sometimes be saved by taking it from the developing tray before development is quite complete, hanging the print up, and drying it rapidly with an electric fan. Generally, however, it is best to let development go as far as it will, when the half-tones and shadows will be definite but the lights will be blank; a second coating and printing, giving longer exposure, will then record the lights as they should be. If development requires more than one hour for completion over-exposure is indicated, and this may be treated either by allowing the print to remain in the water until it is fully developed, the writer having at times allowed prints to develop for forty-eight hours, or if the exposure has been too great for this, by raising the temperature of the water and in extreme cases by adding a slight amount of alkali to the developing water, as indicated in the chapter on carbon printing. The effect of an alkali is much greater in warm than in cool water. The completion of development may be determined by raising the print from the tray and allowing the water to drain from one corner back into the tray—which should be porcelain or porcelain-lined—when a stream of pigment

will be seen running into the tray if development is not complete. When all the soluble pigment has been washed off the water draining from the print will not be discolored, but development may safely be arrested slightly before this point is reached. That is, if only a comparatively slight discoloration of the water is observed there is no danger of the gum and pigment running provided the print is hung up to dry, which should nearly always be done. If the print is laid in a horizontal position a film of water will remain on it much longer than if it is vertical and this film will tend to soften the gum still further and to cause running. A very beautiful effect may be obtained in this manner if the running is but slight, though to secure this effect at its best the exposure must be absolutely correct and development must be arrested at precisely the proper time.

The gum adheres to the paper but slightly when water-soaked, and for this reason values may be lightened to almost an unlimited extent during development. To effect this lightening various methods may be employed, these being arranged below in the order of their vigor, the first producing the least effect. The print should have been soaked for at least ten minutes before starting forced development, and the effect is greater if soaking has been longer than this.

1. The print is supported at an angle on a sheet of glass and a stream of water is allowed to flow gently over it from a hose or graduate.

2. The sheet of glass carrying the print is set nearly vertical and the print is sprayed with cold water from an atomizer, the most desirable being the kind designed to spray heavy liquids, such as albolene. The effect of using the atomizer is more vigorous and more concentrated when the nozzle approaches close to the print, diminishing in power and spreading over a larger area as the nozzle recedes from the paper.

3. The print being nearly horizontal, a succession of drops of water is allowed to fall on it from a slight elevation, either from a hose or from a graduate.

4. The print is lightly brushed while under water with a soft camel-hair brush.

5. The camel-hair brush is used while the print is out of water.

6. The end of a hose which is attached to the faucet is pinched up and a fine stream of water is directed against the print, the latter being supported on a sheet of glass.

7. A stiff bristle brush is used on the film.

The writer has also successfully used the sawdust soup that is employed for Fresson, treating the gum print as though it were in the other medium.

Whatever method is used the print should be rinsed in clean water before being hung up to dry.

It is difficult to apply any of these methods so as to produce a decided change in values without interfering with the photographic quality of the print by introducing brush marks or other indications of

manipulation, and for this reason automatic development is advised whenever it will produce the desired result, since an evident mixture of mediums, that is, photography and hand-work, is a violation of unity and as such is to be condemned from an artistic point of view. To be sure, it is possible to modify values, as has been said, to an almost unlimited extent, and some workers use the gum process with this end in view, producing effects which bear some resemblance to a charcoal sketch or a pastel drawing, but this practice cannot be too severely condemned on artistic grounds.

If artificial development is to be used, it is usually best to employ a coating mixture which contains enough pigment to give the paper a slight stain, then allow automatic development to go as far as it will, and do the hand-work, so far as may be, on the residual stain. If this is done, the hand-work is less likely to be apparent.

MULTIPLE PRINTING.—Gum being a short scale process, it is impossible to render satisfactorily in one printing a negative having a long range of tones, and if this type of negative is employed a curve plotted for the resultant gum print would have much the same appearance as the characteristic curve of the plate given in Chapter IV, the shadows being flat and lacking in detail, the lights being blank and only the half-tones having the proper gradation. Also it is impossible—or nearly so—to obtain in one printing of gum a rich black, but both

of these objections may be overcome by multiple printing, for repeated additions of pigment to the shadows will give any desired depth of color, and it is possible to print in such a fashion as to render the entire scale of the negative satisfactorily.

If the paper is coated and printed deep enough to record the gradations in the lights of the negative, then is dried, coated again and printed more lightly, the half-tones will be recorded over the dark ground left by the half-tones and shadows of the first printing. A third printing lighter than either of the others will record the shadows of the negative and give the desired result. Some workers elect to print for the shadows first, then for the half-tones and finally for the lights, but the writer prefers to follow the order given above, since the other method results in the shadows of the first printing and the half-tones of the second being covered by a gradationless layer of pigment resulting from the overprinting of the thinner portions of the negative in the later coatings. Some method of registration must be used to insure that the outlines of successive printings coincide, and many have been suggested, some of them being as follows:

1. A mask is used as for multiple carbon printing.

2. The paper is cut slightly smaller than the negative and is laid on it in the printing frame, pencil marks being made at the ends and sides, these marks, which of course are on the back of the paper and on the face of the negative, being made to extend about

one-half inch in from the edge of the paper and as much on the face of the negative, the marks being brought into coincidence for successive printing. This method is particularly applicable to enlarged negatives, in which case the large negative may be made on a piece of bromide paper or a dry plate a size or two larger than the finished picture is to be, so that none of the picture will be lost through cutting the printing paper smaller than the negative.

3. A third method is to use a printing frame a size larger than the negative, to lay the back of the printing frame upside down on a table, to place the paper film side up on this, lay the negative face down on the paper, and at each corner of the negative make a diagonal pencil mark on the paper, this mark extending perhaps an inch beyond the negative. The glass of the printing frame is then laid on the negative and the frame itself is placed in position, after which the whole is turned over and the back is clamped in place.

4. A printing board is used instead of a frame, this board consisting of a drawing board over which one or two thicknesses of felt have been stretched, the felt being fastened by means of tacks in the edges of the board. The paper is laid face up on this and the negative is placed face down on the paper. Stout pins are then thrust into the board in contact with the edges of the negative and the whole is placed to print. For subsequent printings the pins are replaced in the original holes in the paper and the

negative is slid into position. This gives accurate registration provided the paper has been soaked and allowed to dry before the first printing in order to shrink it, but it is obviously inapplicable to paper negatives unless a piece of glass is laid over the negative, and cannot be satisfactorily used with glass negatives smaller than 11×14, the weight of smaller pieces of glass being insufficient to keep the paper flat.

The writer uses the first method for negatives up to and including 11×14 inches, but for those 14×17 or larger he prefers the fourth.

Of course it is not necessary that successive printings be in the same color any more than is the case with carbon, but generally speaking the lighter colors should be put on first and the darker ones afterward, as in the reverse instance the effect is apt to be unpleasant. The writer prefers to make the original negative such that the entire scale of tones may be rendered by one printing of gum and to use successive printings solely to add richness and depth. The negative for this technique should be very soft and should be as thin as possible, having no suggestion of fog or heaviness, partly because any veiling of the shadows will make it difficult to judge the printing time and partly because it will be difficult to secure a bright print from a veiled plate. The extreme shadows of the negative should be almost clear glass, but the lower tones should have

full detail and gradation. This type of negative will be secured by giving slight over-exposure and considerable under-development and will be of a sort that will give a moderately bright but not strong print on a medium grade of chloride paper. It may be remarked that the production of a negative precisely suited to gum printing is probably the most difficult technical feat in the realm of pictorial photography, with the exception of the production of a set of negatives suitable for three-color gum work.

The beginner usually makes the mistake of expecting the first printing to look like something when it is finished, and of becoming discouraged when this turns out not to be the case. But a good first printing should not be more than a rather distressing travesty of a completed print; vigor and strength will begin to appear with the second or third coating.

The Actinometer.—It was said above that an actinometer may be made which will facilitate accuracy in multiple printing, and for the information of workers who may desire to make such an instrument instructions are here given, these being taken largely from the very complete and thorough work of Dr. Kösters, entitled "Der Gummidruck."

A sheet of tracing paper twelve inches long and four inches wide is fastened over a clean piece of glass the same size by a touch of glue at each corner; another piece the same width but eleven and a half

inches in length is fastened over this so as to leave one-half inch of the first uncovered; a third piece the same width and eleven inches long is then fastened over the second so as to leave one-half inch of this and one inch of the first without other covering. Successive pieces are then glued in place, each piece being one-half inch shorter than the previous one, so that a photometer of twenty-four steps results.

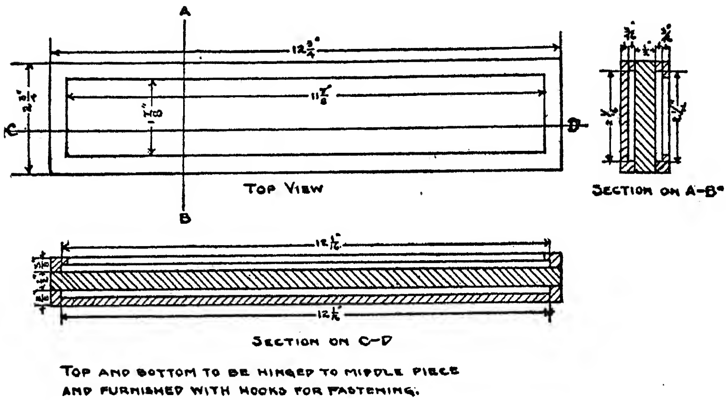


FIG. 43

This is then cut in two so that two photometers each twelve inches long and two inches wide are obtained. These may be used either in ordinary printing frames or in special cases made for them as shown in Figure 43. The lower portion of this case serves to carry pieces of test paper.

It is not strictly necessary to determine the factor of this instrument, but it is convenient to have this information and it may be obtained in the following

manner: Slips of P. O. P. are cut of the proper size and one is placed in the instrument and exposed to light for a definite period, say twenty seconds; the highest visible tint on this print is then noted (the different steps should of course be numbered in heavy figures, using black drawing ink), the piece is then replaced in the photometer and exposed to light for another definite period, say four hundred seconds. If now the time required for the P. O. P. to show a visible tint when exposed without the photometer is called "t" and the factor of the instrument is called "a" the time required for the paper to show a tint under the first step of the instrument will be $t \times a$ and the time required for it to show a tint under the second step will be $t \times a \times a = ta^2$, since each gradation of the photometer absorbs a certain percentage of the incident light. In like manner the time required for the next step to appear will be $t \times a \times a \times a$, that is, ta^3. Then the time required for step "m" to appear will be ta^m and for step "n" to appear will be ta^n. Calling the total time required for "m" to appear "x," and the total time required for "n" to appear, "y," then we have

$$ta^m = x$$
$$ta^n = y$$
$$\frac{ta^n}{ta^m} = \frac{y}{x}$$
$$a^{n-m} = \frac{y}{x}$$
$$a = \sqrt[n-m]{\frac{y}{x}}$$

To take a concrete example, suppose tint 4 appears

in twenty seconds and tint 8 appears in 5 minutes and 20 seconds, then we have

$$\frac{a^8}{a^4} = a^4 = \frac{320}{20} = 16$$

and a equals 2; that is, the factor of the instrument is 2, which means that each tint requires twice as long to appear as the preceding one, since each step of the paper absorbs half of the incident light. Paper which absorbs this much light would, however, give an unnecessarily extended scale of gradation and would be unsatisfactory, the most desirable factor being between 1.2 and 1.25. It should be noted that most samples of tracing paper will turn yellow with exposure to light and the factor will then increase so that the photometer must be renewed from time to time. It is convenient to determine the factor of each step of the instrument, which can of course be done by obtaining the successive powers of the fundamental factor. That is, if $a = 1.2$ this will be the factor for the first step, the factor for the second being $(1.2)^2$, that for step three being $(1.2)^3$, and so on. These powers are most readily obtained by the use of a table for logarithms, which is practically necessary in obtaining the fundamental factor of the instrument. This fundamental factor should naturally be the average of a half dozen or more readings, since possible errors are thus minimized.

The method of using this photometer is this: First the speed and scale of the coated paper are determined, and this is done by placing a strip of the

paper to be used for printing in one of the photometers and a piece of P. O. P. in the other, both photometers being then exposed to light simultaneously for a definite length of time, say ten minutes, and when they are taken in the highest visible tint on the proof paper is noted. The strip of gum paper is then allowed to develop automatically for an hour in water in room temperature, when the highest and lowest tints visible are read. We will suppose that the highest visible tint on the P. O. P. is 12 and the highest visible on the gum paper is 14; this then means that to print to a certain depth on this gum paper we must always print two tints lighter on P. O. P. If the lowest tint which is not blocked up on the gum paper is 8, say, then it is apparent that this particular coating mixture will register 6 steps of the photometer. The quality of the negative is then determined by putting a sheet of P. O. P. into a printing frame with it and a piece of P. O. P. into one of the photometers. The negative and photometer are then put out to print and are printed simultaneously until the P. O. P. under the negative is printed proof deep, when they are taken in and the highest tint visible in the photometer is read. We will suppose this to be 10, and this determines at once the intensity of the lights in the negative and probably the scale of gradation also. Then when we come to print in gum from this negative it is apparent that we shall wish to print to tint 10 of the gum paper and this is done by putting the paper under the

negative and a strip of P. O. P. in the photometer to print simultaneously, the exposure being just long enough to render tint 8 visible on the test slip, for we found that the gum paper prints two tints more rapidly than the P. O. P.

If this method is followed practical certainty in printing results, although slight errors may be introduced owing to the difficulty of judging the highest visible tint in the photometer. Still, variations in the temperature of the developing water will take care of such errors. It is apparent that if the scale of the negative is measured by 10 tints of the photometer, it will be necessary to give the paper two printings of this particular gum mixture, since we found that the coating in question registered 6 steps of the instrument. Should the density of the lights in the negative be represented by tint 15 of the photometer three printings would evidently be required. Obviously, in the first case the second print would be such as to register tint 4; that is, printing would be continued until tint 2 of the photometer becomes visible, and in the other case the second printing would be for tint 7 and the third for tint 1.

The relative sensitiveness of a bichromate-sensitized colloid film as compared to P. O. P. is greater in a weak light than in a strong one, so that if the determinations indicated above of the relative printing depths of P. O. P. and of gum paper are made on a bright day during the hours when the light is

strongest, it will be found that printing by this method will result in excessive exposure of the gum paper when the work is done early in the morning or late in the afternoon or on a dull day. This error may be avoided by using in the photometer freshly prepared strips of paper coated with a bichromate-sensitized gum film, this being made by coating a piece of paper with a standard mixture of gum solution and sensitizer, using no pigment at all, and this is dried in the dark, when it may be cut up into slips and used for test purposes. Evidently the relative sensitiveness of this test paper to strong and weak light will be the same or nearly the same as that of the printing paper, and the numbers of the actinometer may be read directly upon it, there being no pigment to mask the color of the bichromate image.

Some workers give ten or twelve printings and the writer has even heard of one who habitually gives from twenty-five to thirty, but any such number of printings is quite excessive, since a suitably adjusted coating mixture will give any richness of shadows which may be required in four printings and will render the gradations of practically any negative in from four to six.

FAILURES.—As has been said, gum is the most flexible of all printing mediums, and for this reason failures are more apt to occur than with any other. If, however, the worker has a good grasp of the principles of the process he will be able to determine for

himself the cause of any particular defect, though a few of the commoner ones are noted here.

Over-printing and under-printing of course manifest themselves by the print either requiring an undue length of time for development or developing too rapidly. If the trouble is over-printing the lights of the picture will remain dark, but the margins of the print which were protected by the rebate of the printing frame will develop clear. Should the margins fail to develop clear in half an hour, the trouble is due to an excess of pigment in the mixture, the paper being stained; to staleness of the paper; or to the fact of the paper having been exposed to light when not in the printing frame.

If the print flakes in development, that is, the gum peels off in patches instead of developing smoothly, the trouble is due to one of five causes: 1. Excess of pigment in the coating mixture, this of course indicating itself by stained lights. 2. The application of too thick a coating of the mixture to the paper. Only experience can determine the proper thickness of the coating, but it may be said that the prepared paper should not in general appear black but rather of a medium or dark gray, the coating being thin enough to allow the paper to be seen slightly through it. 3. Excess of gum in the coating mixture. This will show itself at the time of coating the paper, since too thick a mixture will be difficult to spread and will become tacky so rapidly that it will be difficult, if not impossible, to blend it properly. 4. Too much alkali in the developing

PRAGUE: WINTER ON THE RIVER
BY DOCTOR D. J. RUZICKA
From a Chlorobromide Enlargement

water. 5. Excessive amount of size in the paper. If this last-named fault is the cause of the trouble it can be determined only by the fact that the defect is not due to any of the other causes given.

If the print shows a streaky texture this may be due either to faulty blending or to removing the print from the developing tray too soon and hanging it up to dry. In the former case the streaks will be comparatively fine and may be in any direction, either vertical, horizontal or oblique. In the latter case they will be broader in character and their direction will of course depend on the position assumed by the print in drying. Streaks caused by faulty blending will be apparent on the paper before it is printed.

A general running of the image is due to underprinting or to insufficient development. Underprinting will of course show itself in the developing tray.

Staleness of the paper will manifest itself by a refusal to develop, and is difficult to distinguish from the effect of excessive pigment in the mixture when the excess is not sufficient to cause flaking. Gum paper deteriorates very rapidly and should be kept in a sealed platinum tin with preservative unless it is to be used immediately after drying. Even if kept in this manner it does not remain in first-class condition for more than a day, and may become entirely useless in two or three days, owing to the insolubilization of the gum which takes place even without exposure to light.

CHAPTER XV

Technique of Gum-Palladium

The reasons for adding a printing of gum to a palladium print have already been given, and little can be said concerning the technique of the process, since this is covered under the headings of palladium and gum, the process consisting simply of making a palladium print and using that as a paper on which to make one or more gum prints.

It will be found convenient to make the palladium print on a sheet of paper somewhat larger than the negative, since this facilitates the application of the gum coating. This, however, is not strictly necessary, for by careful working it is possible to coat up to the very edges of the print.

In practically all cases it will be found desirable to size the palladium print before applying the gum, and this may conveniently be done with a boiled starch paste as indicated in the chapter on gum printing, this being easier to prepare than the gelatine size and being usually sufficient, since it rarely happens that more than one printing of gum will be given. The necessity for sizing is due to the fact that the various chemical baths which the palladium print goes through have a strong tendency to remove the size from the paper.

The gum mixture should ordinarily be rather weaker in pigment than for straight gum printing, since the palladium print itself furnishes fairly rich blacks and the purpose of the gum is to add somewhat to their value.

It is not necessary to adopt any special methods of registration in gum-palladium work, this being very easily effected by placing the print on the negative in a printing frame, holding it up to a concentrated light, such as a 100-watt Mazda lamp, in a relatively dark room and shifting the print about with the fingers until it is seen to be registered, when the frame is carefully lowered to the table and the back clamped in, the print being held in position on the negative while clamping the first section of the back in place. If a printing frame the size of the negative is used it will be found desirable to trim the print about one-sixteenth inch smaller all around than the negative, before attempting to register. The fact that this method is possible in gum-palladium but not in gum is due to the much greater opacity of the palladium image as compared to that of the gum. If two or three printings have been given to a gum print it may then be registered by this method if desired, and in any case it will be easier to register the print if the negative is toward the worker than if it is between the print and the light.

Development of a gum-palladium print should in general be largely automatic, since brush work is more noticeable in this case than in straight gum

printing, owing to the much more definitely photographic character of the palladium image. It is, however, possible to intensify the lights to a certain extent without the effect being conspicuous.

Gum-palladium is useful in many ways, such as for the purpose of obscuring shadow detail which is not desired, or for adding color to the print, but in the writer's opinion its chief value is found in portraiture. Yellow and red, which characterize the major portions of the face, are colors which have strong psychic value; that is, they are unconsciously associated in our minds with light and warmth and hence appear much stronger than their true photometric value; also, in conversing with an individual or in looking at one at a short distance, the attention as a rule is concentrated on the face, so that the clothing appears to us rather indeterminate, except in the case of a noticeably dressed woman. For this reason our ordinary impression of a Caucasian is of a light area surmounting a darker or less defined area representing the clothing. Careful analysis shows that the skin is in reality much darker than white linen and many photographers attempt to render this relationship rather than the true psychic relationship by making the face considerably darker than the collar or other white portions of the cloth, so that they represent accurately a minor truth—the values of the linen—at the expense of a greater one. On the other hand, if the photographer desires to give the true impression he usually endeavors to ac-

complish this through either under-exposure or over-development of the negative, the former obliterating shadow detail by failure to render it on the plate, the second obliterating it by necessitating over-printing of the shadows in order to record the gradations in the lights. Either of these methods gives a scale of tones which is quite as false as that resulting from the technique first mentioned, since both methods extend the scale of tones in the face unduly.

The desired effect may readily be obtained without falsifying the values in the face by making a normal negative, erring on the side of under-development rather than over-, and making from this negative a gum-palladium print, for the palladium will render the scale of the face as it should be rendered and the additional printing of gum will, if properly adjusted, subdue the shadow detail without extending unduly the gradation in the features. In addition, the increased weight given to the shadows by the gum printing without a corresponding increase of weight in the lights will tend to emphasize the latter by means of contrast, and the writer finds that a portrait handled in this manner, especially if it be of a strong-featured man, is exceedingly effective. For children and for women in light clothes it is not so much to be recommended, though a soft negative printed in gum-palladium will in the case of a satin gown give a quality of texture to the cloth

which the writer has never seen equalled in any other printing medium except oil or bromoil.

It is much easier to make a gum-palladium print than to make a gum print, since in the first case it is simply a question of adding a certain amount of weight to an already nearly completed print, and the worker is not as a rule obliged to consider the question of rendering the gradations of the negative with the same care as is necessary in gum printing. It will, however, be found much easier to make a gum-palladium if the palladium print was normally exposed so that the lights are rendered satisfactorily and weight is added merely to the half-tones and shadows than if the palladium print was under-exposed and an attempt is made to add, by means of the gum, gradation which is lacking in the lights. This is due to the fact that in many circumstances the gum process has a tendency to flatten the lights, this resulting from the transparence of the pigment in the upper register unless enough is added to cause flaking in the shadows. Also it will be found that gum-palladium presents a considerable economy of time and effort over multiple gum, for the reason that palladium paper will render shadows as dark and a scale of gradation as full as can be obtained in two or three printings of gum, so that the original palladium print represents in its values the equivalent of perhaps three gum printings, and is made with much less effort. Further, unless extreme care is taken in registering successive printings it will be found that

each additional printing of gum tends to add a looseness to the outlines of the image, even though the registration is not so bad as to give definite double outlines, for which reason gum-palladium tends to preserve the accuracy of drawing of the negative with greater precision than is the case with multiple gum, though the shrinking of the palladium print will often make precise registration impossible. In such a case the most important parts should be registered, and the faulty outlines may often be remedied by a few touches of a pencil on the finished print.

CHAPTER XVI

Technique of Oil and Bromoil and of Transferring

THEORY OF OIL.—Oil printing is practically identical with the reproduction process known as collotype except that the support is paper instead of glass and that a brush is generally used for applying the ink, though in some cases a roller is used for this purpose as in collotype work. If a film of unhardened gelatine is spread uniformly on a sheet of paper and when dry is sensitized with a solution of a bichromate salt, this gelatine film will on exposure to light under the negative be tanned in proportion to the amount of light action; that is, the shadows, which have received the most light, will be strongly tanned, the half-tones less so and the lights least of all. If the sensitizer is then washed out of the film and the print is soaked for a few minutes in warm water, the less tanned portions absorb water more freely than those which have received greater light action, and acquire the property of repelling an oily ink, the degree of repulsion of the ink depending on the amount of swelling of the gelatine.

THEORY OF BROMOIL.—In the case of bromoil the print is made either by contact printing or by enlargement on a sheet of bromide paper which is

developed, fixed, and washed in the usual manner. This print is then treated with a solution of certain chemicals, the effect being to tan the gelatine in proportion to the amount of silver contained in the film. Hence the shadows are most tanned, the half-tones less and the lights least of all. Washing and soaking results in the gradations of the print assuming in varying degrees the power of repelling a greasy ink, exactly as is the case in oil printing.

Theory of Transferring.—The oil or bromoil print is prepared and inked in the usual manner, using a somewhat softer ink than is generally employed. This print is then placed in contact with a sheet of paper, which should not be too heavily sized, and the two are run through a roller press, such as an etching press or a clothes wringer. The result is that most if not all of the ink from the image in the oil or bromoil print is transferred to the uncoated paper and the final result somewhat resembles a lithograph.

Materials Required.—The paper should, as has been said, be coated with a film of unhardened gelatine, and commercial oil papers are obtainable, but the writer finds that the most satisfactory oil paper with which he is acquainted is made by taking a good bromide paper which has not been hardened in manufacture, and which has not received a supercoating of hard gelatine (see page 223), fixing it without exposure to light in a 20 per cent plain hypo bath, washing for one hour in running water, and

drying. The paper thus prepared will keep almost indefinitely, a small amount being sensitized as required. Generally speaking the smooth grade is to be preferred, though in some cases the rough may be desirable.

The sensitizer is a solution of potassium, sodium or ammonium bichromate, and the most generally useful strength is a 2½ per cent solution; that is, 480 grains of the salt dissolved in 40 ounces of water, (25 grams to 1000 cc.) though for some purposes the bath may be used stronger or weaker than this.

A half dozen lintless blotters a size larger than the paper to be printed are necessary, as well as several soft lintless cloths, well-washed linen or cotton handkerchiefs being the most desirable which the writer knows.

Inks will be required, and these may be either the specially prepared inks furnished by the manufacturers of oil printing supplies, or stiff lithographic inks, the latter being obtained from any dealer in printers' inks and being preferably packed in collapsible metal tubes. These inks may be obtained in tubes of varying size and when purchased in quarter-pound tubes are not only quite as satisfactory as the specially prepared inks but cost something like one-tenth as much as the latter. Brushes will be needed, and these are of a special type, being known when prepared for oil printing as "stag foot oil printing brushes" and when purchased of a dealer in painters' supplies as "fitch stipplers, cut slanting." The

French and English oil brushes cost about twice as much as the American made fitch stipplers and are worth the difference. It will be found desirable to have at least three brushes, one about one-eighth or one-fourth inch in diameter for fine work and two about one inch diameter or larger for general use. If prints larger than 11×14 inches are to be made it will, however, be found desirable to have the larger brushes of the largest size which can be obtained, since the use of a small brush on large prints prolongs unduly the time required for inking.

Either gasoline or soap and water may be used for cleaning the brushes, and this should be done immediately on the completion of inking, since if the ink is allowed to dry on the brushes it will be difficult to remove. The brushes when not in use should be kept in paper cones to preserve their shape. A sheet of glass about 8×10 inches or a china palette will be required, and it is convenient to have a palette knife, although this is not strictly necessary. Some medium for thinning the ink will be required at times and this may be either boiled linseed oil, turpentine, megilp or Roberson's or Sinclair's medium. A very small amount is sufficient and an ounce of any of these will probably last the ordinary worker many years.

It is convenient though not imperative to have a board on which to place the print for inking and this may conveniently be made as follows: An ordinary draftsman's drawing board of suitable size is

either given three coats of spar varnish or is covered with oilcloth drawn smoothly over the surface and tacked firmly along the edges. A piece of well-washed muslin slightly larger than the board is tacked to one end of the latter so that six or eight wet blotters may be laid on the oilcloth and the muslin drawn over them, being fastened in place with push-pins.

Sensitizing.—As stated above, the best strength of sensitizer for general use is a 2½ per cent. solution, though it may be used as weak as 1 per cent. if more contrast is desired or as strong as 5 per cent. if softer prints are wanted. Weakening the sensitizer does not interfere with precision in exposure, as is the case in carbon printing, since the image prints out to a certain extent and the time of printing is gauged by the appearance of the paper in the frame. The method of use is the same as in the case of carbon; that is, the paper is immersed for two and one-half minutes and is then squeegeed face down on a clean piece of glass to remove the excess of sensitizer and is hung up to dry in the dark. The use of the ferrotype plate presents no advantage in oil printing and retards drying somewhat, since only one surface of the paper is exposed to the air. As with carbon and gum, sensitizing may be done in an ordinary room, but drying must take place in the dark, oil paper when dry being much more sensitive to light than carbon. A sensitized oil paper deteriorates more rapidly than carbon tissue, and is at its best immediately after drying, though if care-

fully kept it may remain in fair working condition for a few days. A quick-drying sensitizer may be used, and many workers prefer this both because of its greater flexibility and because of the rapid deterioration of sensitized tissue, the spirit sensitizer making it possible to sensitize and print on the same day. The same formula that is given for carbon (see page 217) may also be used for oil paper.

This is spread evenly over the paper with a Blanchard brush or a flat Japanese paint brush, and if a standard amount is used for a given size of sheet the results will be uniform. This sensitizer dries so rapidly that it should be applied by artificial light or in weak daylight. The paper will dry in from five minutes to half an hour, depending on the proportion of alcohol and on the atmospheric conditions, the stronger sensitizer being of course used for soft results.

PRINTING.—The best type of negative for oil printing, that is, one which will exhaust the possibilities of the process, is one which, although by no means harsh, should nevertheless have more contrast than for gum work. It will give a moderately bright print in palladium, though it will by no means exhaust the scale of palladium paper, and since the oil process tends to soften outlines somewhat these should have in the negative rather more firmness of drawing than for an equivalent amount of diffusion in palladium or carbon.

Printing is done by sunlight or strong artificial

light and should be continued until the highest lights of the picture have a slight tone, unless, as is sometimes the case, a pure white is desired in the lights, the image showing in a yellowish-brown tone on a yellow ground. When exposure is complete the print should at once be washed in water at about room temperature until all the free sensitizer has been removed. It will not be possible to wash out all traces of the image, since a certain amount of tone will always remain in the shadows. Washing should not be delayed, for the continuing action of light is the same with oil as with carbon and gum. After the print is thoroughly washed it may either be soaked and inked at once or may be hung up to dry and kept for an indefinite period, any further change in the gelatine film taking place with extreme slowness. The writer has known of prints which had been thoroughly washed being inked satisfactorily six months after printing, but the film will in time deteriorate and the ink will not take properly.

It is necessary to employ a safe-edge and this should be rather wider than for the carbon process, half an inch being none too much, since the purpose of the safe-edge is to keep the inking brush from touching the wet pad on which the print rests during inking, for if the brush takes up any water it will not deposit the ink properly. The safe-edge also furnishes a convenient indication of the correctness of both exposure and soaking, since if the print is

properly handled the margin will remain clear both in the printing frame and in the inking. Very pleasing effects may be obtained by using paper a size larger than the negative, *i. e.*, 11×14 for an 8×10 plate, printing with a mask in the frame, and leaving the entire margin to serve as a border. If the ink takes on the edge it may be removed before hanging the print up to dry, by wiping with a damp cloth wrapped about the finger.

Soaking.—After washing, the print must be soaked for a few minutes in warm water and no definite instructions can be given for this part of the process, the degree of soaking varying with circumstances. If the print has been over-exposed, warmer water will be needed for soaking than if printing has been normal, increase of temperature in the soaking water causing the film to absorb a greater amount of water than would otherwise be the case, thus giving it a greater repellent effect on the ink. It will be apparent from this that the use of warmer water not only means a higher value in the lights but also gives the print greater contrast, since the lights are more affected than the half-tones and these in turn more than the shadows. If it is found on inking that the print has been soaked in water at too high a temperature, which is indicated by the lights refusing to take the ink properly, it may be allowed to dry out partially. About the only guide which can be given in the matter of soaking is to say that a normally exposed print should be soaked in water at

such a temperature that the gelatine film on the unexposed margins which were protected by the safe-edge should, on rubbing between the thumb and finger, rub off with moderate ease, though this applies especially to commercial oil papers, such a marked softening being unnecessary with the bromide paper. If any doubt is felt as to the sufficiency of the soaking, a corner of the print may be surface-dried and the ink tried on the dry area. If the ink takes on the print but fails to adhere to the safe-edge the soaking is probably correct.

Generally speaking, the soaking should end in water at about 110° Fahrenheit (43° C.), and better gradation will be obtained if the soaking is begun in water at about 95° Fahrenheit (35°C.), the temperature of the water being gradually raised to the proper point, than if the print is placed at once into the warmer water. In case of serious over-printing the water may be used much hotter than this, though excessive heat will probably cause the gelatine of the safe-edge to tear during the inking. When the print has been sufficiently soaked, which will probably require about ten or fifteen minutes, it is lifted from the tray, drained, and placed face up on a sheet of glass or other smooth surface. It is then dabbed lightly with a wad of lintless absorbent cloth until surface-dry, when it is laid on a pile of half a dozen wet blotters or on the inking board described above, and inking may be begun.

If the inking of an oil or bromoil print cannot

be completed in one operation, the print may be set aside and allowed to dry, being re-soaked and inked further at some later time. In such a case, the gelatine cannot be swelled to a lesser degree than at first; it will swell to the original extent, even though cooler water is used than was employed for the first soaking. Increased swelling may of course be obtained by the use of warmer water than for the first soaking, but here again the limit of all subsequent swellings is fixed by the temperature of the water.

INKING.—The final result depends in great measure on the character of the ink and the method of its application, and experience is the only satisfactory guide in these matters. A small quantity of the ink is squeezed from the tube on a clean piece of glass or a china palette and is spread out in a film about one-sixteenth inch thick by means of the palette knife. A quantity of ink the size of a large pea will serve to ink three or four 8×10 prints. One of the large brushes—which are cut to a slant, the ends of the hairs being slightly domed—is dabbed lightly in the ink and is then dabbed two or three times on a clean portion of the palette in order to distribute the ink among the hairs. The brush is then pressed with only moderate force on the print, when it will be found to leave some of the ink on the film. After two or three touches of the brush on the print it must be dabbed in the ink again and the ink distributed as before, the operation being repeated until the print is satisfactorily inked. It will

be found advantageous, when dabbing the brush on the palette to distribute the ink, to dab always in approximately the same part of the palette, since an exceedingly thin film of ink is thus deposited on the palette and the brush will work better than if a fresh spot is chosen each time. Some workers advise inking either the high lights or the shadows up to their proper value at first and then proceeding to the rest of the print, but the writer prefers to ink lightly over the entire area of the print at first, gradually building up to the desired degree of contrast, the effect being thus more directly under the control of the worker. The appearance of the print will probably be very discouraging at first, but inking should be continued, and the image will gradually attain its proper character if the preceding operations have been correctly carried out.

There are two methods of handling the brush, and these produce widely differing results. A slow pressure of the brush on the print deposits ink on the film, whereas a quick "hopping" action removes ink already adhering, this effect being especially noticeable when a clean brush is used. If it is found difficult to deposit sufficient ink to obtain the desired depth in the shadows the ink may be thinned with any of the mediums mentioned above, the least desirable of them being turpentine, and there being practically no choice among the others. The ink will probably be sufficiently thinned if a single drop of the medium is placed on a clean piece of glass and

the palette knife is lightly dipped in this drop, the small quantity adhering being then mixed with the ink. The possibilities of increasing the contrast in this manner are unlimited, since if the ink is sufficiently thinned it is possible to produce an absolute black even on the safe-edge, and a great deal may be done to lighten the values by hopping, this hopping action being easier to effect when only a slight amount of ink has been deposited on the print. It is difficult to describe precisely the method of hopping, but it consists essentially in allowing the brush to strike the film with moderate vigor and removing it suddenly from contact. Some writers say that hopping is done by allowing the brush to fall on the print and catching it on the rebound, but the writer prefers to throw it lightly against the film and then catch it as it leaves the print.

It will be seen that unlimited possibilities of control of relative values and of total contrast inhere in the process, since it is possible to deposit as much or as little ink on a given area as may be desired, even leaving it off entirely, and it is also possible to remove much of the ink which has already been deposited. Some writers advocate inking the print at once for a normal result, afterward lightening portions by hopping, but the writer prefers to work with a guide print, for example, a P. O. P. proof, before him and to deposit ink only where it is needed for the desired pictorial effect, since it is not possible to remove an indefinite amount by hopping. Brush-

holders for hopping may be obtained, these consisting of a piece of spring wire several inches long, having at one end a handle and at the other a device for holding the brush. The writer has found that such a holder is chiefly useful for tearing holes in the gelatine film.

The texture of an oil print is practically always slightly grainy, since each individual hair of the brush deposits a small spot of ink, the image being built up by repeated applications. There is, however, a great difference in the textures obtainable, for if a stiff ink is used and the entire surface of the print is worked over for a long time these minute spots of ink are spread by repeated touches of the brush and the final result will have a fine texture. If, on the other hand, a relatively thin ink is used, so that the desired gradations are rapidly built up, the texture will be coarse. An 8×10 print may be inked up to full contrast in ten minutes with a thin ink, when the texture will be decidedly coarse. If the stiffest possible ink is used with a view to obtaining a fine texture a print of this size may require an hour or more for complete inking.

Although it is possible to apply a thin ink over a stiff one, it will be found that a stiff ink will refuse to adhere over a thin one unless the latter has first been dried.

As has been said, it is possible to ink a print to a certain depth and then dry, resoaking and completing the inking at a later date, but the writer prefers

THE BUBBLE
BY ANNE BRIGMAN
From a Bromide Enlargement

to finish a print at one sitting, for he feels that by this method the best results are obtained, the effect being not only better technically but being also freer and more spontaneous from an artistic point of view. If the print has been dried and resoaked, it will be possible to apply ink by dabbing, but hopping will not remove any of the first application.

If the inking is to be completed at one operation, it will probably be necessary, especially if large prints are being made, or if a very fine texture is desired, to have the humidity of the air in the workroom decidedly higher than normal, to keep the gelatine from drying out during the process of inking. In fact, it is always desirable to have the humidity as high as possible, and it may even prove out of the question to use oil or bromoil in winter in a house which is heated by a hot-air furnace.

A new brush will probably shed hairs in great profusion on the print, these being either pulled out of the brush or broken off. It is well to remove each hair as soon as it is observed, by lifting it on the point of a needle or knife, which may very readily be done without injury to the print. If the hairs are allowed to accumulate on the print they will leave marks when working over them and these marks will have to be spotted out in the finished print. After two or three prints have been inked, the brush will probably cease to shed hairs, or at all events will lose one but rarely.

Drying and Degreasing.—When the print is satisfactorily inked it should be set to dry and should be pinned up by the four corners in a vertical position, since if it is laid horizontally dust will settle on it, and if the corners are not firmly held it may curl up and crack when straightened. Drying will take from two hours to two weeks, depending on the stiffness of the ink and on the amount applied. When the print is thoroughly dry it may be worked on freely with a pencil eraser to lighten values, or ink may be applied to a given area with the brush, though it must be remembered that ink will adhere to the dry print much more freely than when it is wet and that it will adhere uniformly over the entire surface.

The finished oil print has always a certain lustre, this being due to the medium in which the pigment is ground. Should this lustre not be desired it may be removed by soaking the print for from five to fifteen minutes in gasoline or benzole—preferably the latter—and this soaking should take place as soon as the ink has become thoroughly dried and not until then, for if it is done too soon the pigment will be removed from the paper and if it is left too long the oily medium will not be dissolved from the ink.

General Remarks.—Anyone who has followed the foregoing description with care will be able to induce for himself the cause of any particular failure, but a few general indications may be given.

Over-printing or insufficient soaking will give too dark a print, but these faults are readily differentiated, since with over-printing and proper soaking the print will have the proper degree of contrast and the margins will remain clear, whereas with correct exposure and insufficient soaking the print will be flat and lacking in contrast and the margins will take the ink.

The effect of under-printing is, of course, obvious.

Excessive soaking may cause the gelatine of the safe-edge to tear under the brush and will cause the high lights of the picture to refuse to take ink. In extreme cases over-soaking will cause tearing of the film in the lights.

Too stiff an ink will refuse to adhere to the lights and too thin an ink will adhere too readily, the former defect being seldom found. As a corollary to this it may be noted that a stiff ink gives contrast, whereas a thin ink gives flatness.

Should the print be thickly covered with fine black specks, this is probably due to an excessive amount of ink on the brush, and the latter may be cleaned sufficiently to permit of continued use by rubbing on a clean cloth or piece of blotting paper. Should the print show a number of small white spots, these are probably due to the brush having become wet through touching the blotting papers. If the brush cannot be sufficiently cleaned on a dry

cloth it must be washed out and allowed to dry for several hours.

The brushes should be cleaned immediately after use, and if gasoline is used they will probably be dry enough to use in an hour or two, but if they are cleaned with soap and water they will take three to four times as long to dry. They should be dried in the paper cones in which they are kept, or the hairs may spread and the brush soon become useless.

It will be found that fixed-out bromide paper has a much thicker coating of gelatine than the commercial oil paper, for which reason it permits the use of stronger negatives. It should be noted that if a hypo bath containing alum is used for fixing, the paper will probably be useless for oil printing, since this process depends on the fact of the gelatine not having been tanned.

Should it be found that the inking is not proceeding satisfactorily, the print may be cleaned with gasoline, dried and resoaked.

BROMOIL.—A well-known authority on bromoil states that this process will give a longer scale of gradation than oil, but the present writer has not found this to be the case. It is true that if the commercial oil paper is used, the scale is short, owing to the thinness of the gelatine emulsion; but if a sheet of bromide paper is fixed in a plain hypo bath, without exposure to light, and is then washed, dried, and used for oil printing, it will render quite as long a scale of gradation as though used for bromoil.

THE NEGATIVE.—A negative suitable for use with the bromoil process will be in general much softer than one suitable for oil printing, though this depends somewhat on the paper used.

THE BROMIDE PRINT.—For developing the bromide print it is best to use amidol, since this, working without alkali, has no mechanical effect on the gelatine. However, this is by no means imperative, and any good developer may be used.

It is not absolutely necessary to develop the bromide print to infinity, and if a soft print from a strong negative is desired, this may be obtained by over-printing, using the developer dilute, and arresting development when the lights are satisfactory, before the shadows have reached their full depth. The writer feels, though, that more satisfactory results are secured if the negative is properly adjusted to the paper, so that the print is developed as far as it will go.

Fixing must be done in a 20% or 25% solution of plain hypo; if an acid alum hypo is used, the gelatine will be so hardened that no swelling sufficient to be of value can be achieved.

It has been noted, in connection with carbro work, that many American papers have received a supercoating of hardened gelatine in the course of manufacture, and that practically all of them have been specially hardened. These treatments make the use of such papers impossible for bromoil as well as for

carbro, but some manufacturers will supply non-hardened and non-super-coated papers on order, if the purchaser specifies "For Bromoil." Several English bromide papers are specially treated to make them adaptable for bromoil work, these being obtainable through various importing houses, and having proved very satisfactory indeed so far as the present writer is concerned.

The bromide print should be by no means a strong one, for if the shadows approach the full depth possible to the bromide process it will be difficult to obtain complete rendering of the shadow detail in inking. It should be borne in mind that softness in the bromide print will not interfere with the obtaining of a full rich black in the finished print, since ink may be added to practically an unlimited extent.

BLEACHING.—The purpose of the bleaching solution is to tan the gelatine by reaction between the bleacher and the silver image, and there are formulæ almost innumerable for this purpose, different workers having their especial favorites. The writer has found the following two formulæ to be thoroughly satisfactory:

Water	32	ounces	1000.0 cc.
Copper sulfate	600	grains	40.0 grams
Potassium bromide	600	grains	40.0 grams
Potassium bichromate	110	grains	7.5 grams
Hydrochloric acid c p	2½	drams	10.5 cc.

Bleach, wash, and fix in

Water	32	ounces	1000.0 cc.
Hypo	3	ounces	90.0 grams

Wash well, and dry.

Water	32	ounces	1000.0 cc.
Copper sulfate	175	grains	12.0 grams
Sodium chloride	1000	grains	70.0 grams
Potassium bichromate	12½ to 65	grains	1.0 to 5.0 grams
Hydrochloric acid c p	q. s. to give a clear solution.		

Bleach, wash, fix, and wash as above.

Increasing the amount of potassium bichromate increases the tanning action, and the worker should experiment for himself with the paper he wishes to use, since different papers require different treatments. If the bleacher is used warm (up to 100° Fahrenheit or 38° C.) greater relief is obtained, and this is sometimes necessary in the case of a hard gelatine. A gelatine which is so hard as not to respond to the use of a warm bleacher, and hot water for soaking, may often be improved by soaking for a few minutes in a 3 per cent solution of sulphuric acid C. P., which also may be used warm. The acid bath, however, will rarely be necessary if the print is of the proper quality and has been fixed in plain hypo. Greater swelling may also be secured by the addition of a very small amount of alkali to the soaking water, but the results thus obtained are likely to be uncertain. The bleacher given above keeps well and may be used repeatedly, but it is generally preferable to make it up fresh for each batch of prints, since more uniform results are thus obtained. The fixed and washed print is immersed in the bleacher until no further action is observed, although the image will not be entirely removed. It is then washed in running water until free from bleacher, when it may either be inked or may be

dried and reserved for future inking. Drying is not imperative, but better results are obtained if it is done, since the full tanning action of the bleacher is not secured otherwise. Of course, a number of prints may be bleached at a time and kept, but it is not advisable to postpone inking for more than a few weeks at most, though bleached prints have been successfully inked six months after treatment. It is well to fix the print in a plain hypo bath after bleaching.

SUBSEQUENT TREATMENT.—The subsequent technique of the printing (that is, the operations of soaking, inking, drying and degreasing) is identical with that used in the case of oil printing.

TRANSFERRING.—Transferring is simply a matter of placing the oil or bromoil print in contact with a sheet of comparatively absorbent paper, that is, a paper which is not too heavily sized, placing one or more pieces of felt or of etcher's blankets on the two, and running the pack through a press such as an etching press or a clothes wringer. Almost any charcoal paper will work satisfactorily, and many other papers will be found useful, although the Japanese vellums and tissues are so soft in texture that the fibres are likely to adhere to the original and the transfer paper will be roughened in places when the two are separated. With care, however, very beautiful results may be obtained with such papers. In the case of some stocks, it may be desirable to use the transfer paper slightly damp, and this condition is

attained either by dipping several sheets at once quickly into water, then leaving them for some hours between blotters and under heavy pressure, as in a copying press, or if it is intended to moisten a single sheet, it may be quickly dipped, placed between blotters, and run through the transfer press. As a rule, only a very slight dampening is required.

If it is intended to transfer, the oil or bromoil print should be inked with a comparatively thin ink, since a stiff ink will not adhere satisfactorily to the transfer paper. The use of a thin ink, as has been stated above, causes a granular appearance in the oil or bromoil print, but the operation of transferring modifies this to a great extent by spreading out the small spots of ink, thus giving a texture approaching the close texture resulting from the use of a stiff ink in straight oil or bromoil work. The outlines will not, however, assume the distinctness of those in an oil or bromoil which has been inked with a stiff ink. One of the ablest of the English workers in this medium told the writer that he uses the original bromide or oil print simply as an indication of the outlines, relying almost entirely on the brush action for securing the desired values, and stating that the ink employed is so thin that a 12×15 print is fully inked in ten or fifteen minutes. Rapid working is far more necessary if the print is to be transferred than otherwise.

In order to prevent the print from sticking to the transfer paper it is sometimes advised to give the

former, prior to soaking, an immersion of two minutes in a 1 per cent formaldehyde solution, but the necessity for the formaldehyde bath may be avoided by allowing the water to dry out of the film slightly before transferring, the water drying out much more rapidly than the medium in which the ink is ground. A fairly heavy pressure should be used, although it is impossible to give any definite information on this point, since the pressure necessary will vary with the stiffness of the ink, with the quality of the transfer paper and with the result desired. The transferred print will of course be reversed as regards right and left, and allowance must be made for this in printing the original oil or bromoil if it is imperative that the completed picture be the right way around. The oil or bromoil print should be supported on a flat board or piece of sheet metal (which may be the bed of the press) and two or three pieces of blotting paper, of etcher's blankets, or of a heavy upholsterers' felt should be placed over the transfer paper whether the clothes wringer or the etching press is used, since if this is not done uneven pressure may result, causing the ink to transfer more heavily in some portions of the picture than in others.

Multiple Printing.—After the oil or bromoil print has been transferred, it may be soaked and inked again, and either be left as it is, or used to make another transfer, or used to add a second or third printing to the first transfer. If multiple print-

ing is to be done, registration marks should of course be made on the oil print and on the transfer paper when the first transfer is made. Also, it is highly desirable, for this work, to use a special transfer press in which the bed is geared to the roller. Most presses are so constructed that the bed, with the print pack, is carried under the roll entirely by friction, in which case there is danger of the print slipping on the transfer paper, something that is of relatively little consequence in single printing, but is disastrous in multiple work. The writer knows of only one American press that is properly designed in this respect, namely, the Transit press built by Partington, Inc., of Cincinnati, Ohio.

Even in single transfer, it will usually be found that the first transfer from an oil or bromoil is rather weak and unsatisfactory, subsequent ones being of much better quality. Owing to mechanical characteristics, the general limit of transfers is about six from one oil or bromoil print, but with care this may be increased.

Most writers lay special emphasis on the fact that it is possible to modify relative values to an unlimited extent in oil or bromoil work, and this fact is obviously of primary importance, it being seldom the case that a direct transcript from nature is artistically satisfactory, but in the author's opinion the fundamental value of these processes is found in a deeper psychic quality than this. It is well known that the chief value of any graphic art, and even of

the crafts, depends on the fluent and irregular action of the hand, the very precision of mechanical carving, for example, operating to render it uninteresting when compared with handwork. Photographers have felt this mechanical quality in the productions of the camera, and have endeavored to avoid it by brush-development of gum prints, by etching on the negative, and by other devices, but these are not satisfactory solutions of the problem, the results often showing their hybrid character and, further, losing the greatest advantage of photography, the perfect rendition of outlines and gradations. Thus, in platinum, gum-platinum, and most other mediums we have either a print compounded of photography and handwork—always an abomination—or one in which, beautiful though it may be in outline, gradation and tone, we always feel the machine, and the effect can never reach the highest pitch of artistic expression. The worker in oil, however, has at his disposal a medium in which he can render admirably (though not perfectly) the very delicate gradations of light on surfaces and the precise outlines of the subject, or can vary at will either outlines or gradations, all without losing the beauty of the photographic image, and, in addition, can by skilful manipulation of the brush and the ink vary the texture of the image in different parts of the print. A platinum print may be very beautiful, but it remains fundamentally a product of a machine, whereas an oil print necessarily possesses, to a

greater or less degree, depending on the skill and feeling of the worker, the personal touch so prized by artists and art lovers, and may be so imbued with the personality of its maker as to rise to the very highest levels of graphic art.

CHAPTER XVII

Technique of Photogravure

Theory.—A smooth copper plate is burnished and thoroughly cleaned and is covered with a fine dust of asphaltum powder, which is caused to adhere to the plate by heat. A carbon print is then made from a glass positive and transferred to the grained copper plate, stripped and developed. After the carbon print is dry, the plate is immersed in a bath of perchloride of iron, which possesses the property of dissolving copper. Since the carbon print consists of varying thicknesses of gelatine, the etching bath penetrates this film and attacks the copper under the thinnest portions of the film first, then under the next thicker and so on until it has etched the copper to a satisfactory depth under the thickest portions of the carbon print. Since the carbon print was made from a positive it follows that the print itself is a negative and the thinnest portions are in the shadows of the picture, consequently the copper is etched deeper in the shadows than in the half-tones and deeper here than in the lights. Also, the copper is etched only where it was not protected by the grains of asphaltum powder, so that the final result after cleaning off the gelatine film and the asphaltum

dust is a copper plate etched deeply in the shadows, less deeply in the half-tones and least of all in the lights, but having only a certain proportion of its surface etched. This plate is then inked with an oily ink which is worked well into the little depressions made by the etching fluid, and the surface is wiped with cloths and with the edge of the hand so as to remove all the ink from the surface, leaving that which is held in the little hollows. A sheet of paper is then laid in contact with the copper plate and pressure is applied to it. The result is that the paper is forced into the little depressions of copper and lifts the ink out, and since there was more ink in the shadows than in the half-tones—the former being more deeply etched—and more in the half-tones than in the lights, a positive print is produced.

THE COPPER PLATE.—This should be of the best grade of copper and should be bought already smoothed, burnished and bevelled, since although the worker can prepare the plate for himself, it involves too great an expenditure of time and effort to be worth while. The bevelling is not necessary unless the print is to be on a sheet of paper larger than the plate, in which case the paper will probably be cut unless the plate is bevelled. The plate should be approximately one-eighth inch thick for prints 8×10 inches, although lighter plates may be used for smaller prints. The surface should be examined to make sure that it is free from scratches or pits, since these, unless occurring in the shadows of

the picture, will show in the finished print by reason of their catching and holding the ink. The plate should be cleaned with a solution of caustic soda or caustic potash to remove the grease, and rinsed, after which it is cleaned with a dilute solution of sulfuric acid to remove the tarnish. These solutions are rubbed on the plate with a tuft of cotton, and rubber gloves should be worn during the operation. The plate is rinsed after the treatment with acid and is then polished with Bon Ami applied in the same manner as the acid. After the cleaning it is rinsed and stood up to dry.

Laying the Ground.—There are two methods of graining the plate, which are described below; in the writer's opinion the second is to be preferred. For the first method a dusting box should be used, this being shown in Figure 44, the dimensions given

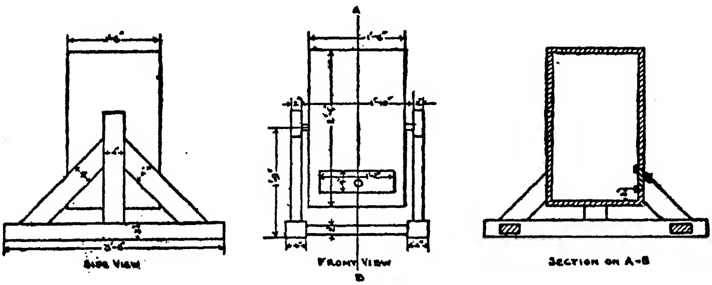


FIG. 44

being sufficient for plates up to 10×12 inches. Into this box is placed about one pint of finely ground asphaltum powder. The door is fastened on, and the

box is rotated several times, the top, sides and bottom being beaten with the hand as the box is turned around in order that any particles of asphaltum which would otherwise adhere to the inside of the box may be dislodged. The box is brought to rest and bolted to hold it steady. The door is then opened and the copper plate is carefully introduced. The copper plate should be supported an inch or more above the bottom of the dusting box, an empty plate box serving to accomplish this, for should the plate simply be placed in the box and the dust allowed to settle on it, it will probably be found on removing the plate that the dust has settled irregularly about the edges, this effect being explained as resulting from air currents set up within the box by the falling dust. This irregularity may be avoided by placing the plate on a sheet of glass an inch or so larger all around than the plate itself, when the irregularities will be on the glass instead of on the copper. The character of the ground depends to a considerable extent on the length of time that the box is allowed to rest before inserting the plate, and also on the length of time the plate remains in the box, since the coarser particles of dust naturally fall first, being followed by the finer ones. For a coarse ground the box may be allowed to rest for about twenty seconds before inserting the plate, and the plate may be allowed to remain in the box for four or five minutes. If a finer ground is desired the box may rest for one or one and a half minutes before

the plate is inserted, but in this case so much of the dust will have settled that it may be necessary to insert the plate three or four times. The quality of the ground should be varied to some extent according to the character of the print desired, for if a fine ground is used it will not be feasible to produce a print with strong shadows, since the deep etching required would cause undermining of the little points of copper, and the shadows would fail to hold the ink properly. After the plate has remained in the box for the determined length of time it should be removed very carefully, as a jar or a breath of air will suffice to scatter the dust. The plate when examined should have the appearance of a fine cloth and the texture of the ground should be uniform. Any large particles which may have fallen on the plate may be removed with a very fine-pointed brush slightly moistened with water. Should the appearance of the plate be unsatisfactory the dust may be wiped off with a tuft of cotton and another ground may be laid. When a satisfactory ground has been obtained the plate is grasped at one end in a small hand vise or pair of pliers, a slip of cardboard being bent over the edge of the plate in order to prevent injury to the copper. The plate is then held over a Bunsen burner or an ordinary gas stove and moved about until the ground is set. The setting of the ground may be determined by the fact of the dust first losing its dull appearance and becoming transparent, and afterward assuming a blue color. If too

much heat is applied the dust may be melted and caused to run together, forming a uniform varnish over the entire surface of the plate, but the heat required to effect this with asphaltum is so great that there is little danger of such an occurrence, it being more likely to take place if rosin or copal is used, as is sometimes done. After cooling, the plate may be examined with a magnifying glass and if the ground is considered insufficient another may be laid over the first and set in the same manner.

The alternative method is to dispense entirely with dusting and to use instead a screen especially made for photogravure and somewhat resembling a half-tone screen. The carbon tissue is exposed under the positive and is then placed in contact with this screen under heavy pressure—a printing frame with pressure screws should be employed—and is exposed to the same printing light for about half as long as was required to print from the positive. The tissue is then transferred to the polished copper plate, stripped and developed in the usual manner, when the gelatine film will consist of a series of fine lines with the gradations of the positive superposed on them, these lines of insoluble gelatine serving to protect the copper from the etching bath in precisely the same manner as the grains of asphaltum. As has been said, the writer prefers this method to the other, since it is more rapid and more certain, the sole drawback being the cost of the screen, which,

however, with ordinary care will keep in good condition indefinitely.

It is also possible to lay a ground by flowing the plate with a solution of rosin in absolute alcohol or by spraying this solution on from an atomizer. The writer has never used a liquid ground, and it is not in general recommended. One of the ablest of photogravure workers has said: "I have found liquid grounds to be troublesome and unsatisfactory."

The Positive.—This may be made on a dry plate or film either by contact printing or by enlarging, and should have only a moderate degree of vigor, for if the positive is too strong the carbon resist will be too strong as well and the plate will be over-etched in the shadows. In extreme cases this over-etching may be so great as to cause under-cutting of the copper where protected by the grains of asphaltum, so that the little hills of metal will break down and the shadows will have less depth than they should. It is also possible to make the positive by contact printing in carbon, transferring the carbon tissue to a piece of ground glass as indicated in the chapter on carbon printing. The transparency must be provided with a safe-edge as in ordinary carbon work and any modification of relative values which may be desired should be made either on the negative or on the positive, since it is difficult to do any handwork on the copper plate or on the resist without such handwork being apparent.

The Resist.—The negative carbon print which is

made from the positive and which is developed on the copper plate is known as the resist, and a special tissue is provided for this purpose, with the idea of making the progress of the etching easier to follow; the regular tissues may be used in an emergency, but they are much less convenient. It is the writer's practice to make a test print, developing it on a sheet of ground glass and keeping a record of the printing time and the temperature of the developing water; any necessary modifications are then easily made when preparing the resist.

In general, the printing time for the resist will be about the same as the time required to make a normal P. O. P. proof from the positive.

The tissues may be sensitized by immersion in the bath for which a formula was given in the chapter on carbon printing and should be squeegeed to a ferrotype plate and allowed to dry in the dark, and the use of a ferrotype plate is of greater importance than for ordinary carbon work, it being imperative to keep the resist free from dust.

When the resist is printed it is transferred to the copper plate precisely as though the latter were a sheet of transfer paper and if the work is properly done adhesion will be perfect, even though transferring is done directly on the burnished copper, as is the case when the screen is used. The backing is stripped off and the resist is developed as in the case of an ordinary carbon print, though every effort should be made to attain such accuracy of printing

that the print may be properly developed at a temperature not exceeding 120° F. (49°C.) or the film may strip off the copper when dried. The resist should be printed and developed in such a manner that the thinnest possible film of gelatine will remain on the copper in the shadows, without, however, losing any of the shadow detail, and it is for this reason that the writer prints a test sheet and develops it on ground glass, keeping a record of the temperature of the developing water. Care should be used to see that no particles of dust get between the copper plate and the resist or adhere to the resist while it is drying, since such particles will probably cause spots in the finished print. Drying of the developed resist should preferably be spontaneous and in reasonably good atmospheric conditions will be complete in the course of an hour or so, though if time is of importance the plate may be flowed two or three times with a 50 per cent solution of alcohol in water, then two or three times with a 75 per cent solution and may finally be immersed for two or three minutes in pure alcohol. After this treatment drying will take place very rapidly, but there is greater danger of the film stripping from the copper than if the drying is spontaneous. When the resist is dried the edges and back of the copper plate should be protected by means of asphaltum varnish thinned with benzole, which may be applied around the edges of the resist with a fine ruling pen, a brush then being used to work up to this line and over the

portion to be varnished. The varnish will dry in the course of two or three minutes and the plate is then ready for etching.

Etching the Plate.—If a single solution of perchloride of iron were to be used for etching it would penetrate the gelatine film so rapidly that the copper would be attacked in the high lights of the picture before it was deeply enough etched in the shadows, and although a single solution is sometimes used in the case of line work it is not satisfactory when a full scale of gradations is desired, and the process must in that case be modified somewhat.

It is a property of perchloride of iron that a strong solution of it will not penetrate a thick gelatine film, and advantage is taken of this circumstance in photogravure work. A fairly strong solution is used at first and this penetrates the thinnest portions of the resist, etching the copper under them, but does not penetrate the thicker parts. When this action has proceeded as far as it will—that is, the bath has gone through the thickest film which it can penetrate—a weaker solution is applied and this penetrates the next thicker portion of the film, etching the copper under this, and at the same time continues the etching in the shadows. A still weaker solution is then used and this extends the action still further and so on, until the weakest solution has penetrated the thickest portion of the resist and has acted on the copper to the proper extent. Thus each solution intensifies the action which has already been begun

and starts etching in gradations lighter than those attacked by the preceding solution. Different writers recommend different numbers of etching baths, Herbert Denison advising six baths of the following strengths, the density being measured with a Beaumé hydrometer designed for heavy liquids: 45°, 43°, 40°, 38°, 36°, and 33°. Other writers say that a good general series is: 40°, 36°, 33°, and 30°. The range of density of the solutions depends on the result desired and on the quality of the transparency and the resist, since a resist having considerable density will require a weaker series than a thinner one, and a resist having little contrast will require a greater number of solutions than a stronger one, for obviously the greater the number of solutions applied the greater will be the contrast in the finished print.

To make the etching baths, take 7 pounds (3½ kg.) of perchloride of iron crystals, add 60 ounces (1775 cc.) of water and dissolve by gentle heat. Take 10 ounces (300 cc.) of this solution and add stronger ammonia, a little at a time, until the solution becomes thick, then add this to the bulk of the solution and boil to expel the excess of ammonia. Allow this to stand for twenty-four hours, bring to a temperature of 70° Fahrenheit (21° C.) and test it with the hydrometer. Should it not test 45° it may be boiled until it does so, the testing in each case being done at the temperature indicated. When it tests 45°

Beaumé a portion is bottled and labeled. The stock solution is then diluted with water at 70° Fahrenheit (21° C.) (if cold water is used the perchloride may be precipitated) until the next weaker step is reached, when a further portion is bottled off, and so on until the complete range of solutions has been obtained. This will make about 16 ounces (450 cc.) each of the six baths indicated above. It will be found that when this has stood for a time a sediment will form and the clear solution may be decanted or siphoned off. These baths improve with use and it is advised that a piece of copper wire be suspended in each of the bottles and allowed to remain for about fifteen minutes before they are used for the first time.

It will be found convenient to have six trays of porcelain, glass, or hard rubber, and to place the six solutions in these in regular order. The plate with the resist mounted on it is lightly dusted and placed in the strongest solution, the tray being rocked and the plate watched carefully. If the resist is too thick this solution may not penetrate the shadows at all and after three or four minutes the plate is lifted out, drained and placed in the next tray. If, on the other hand, the strongest solution penetrates the film—which it will do if printing and development have been correct—the copper will be seen to discolor, and there should be no difficulty at all in observing the action. This discoloration will be seen to spread over the surface of the plate, which should

be allowed to remain in the solution until the discoloration has ceased to spread. When the discoloration has ceased spreading in each solution the plate is drained and transferred to the next weaker bath, where it remains until the time for its removal. It should be allowed to remain in the weakest solution necessary until the high-lights have been completely discolored, when it is rinsed rapidly in hot running water and the softened resist is rubbed off with a tuft of cotton. The asphaltum ground, if such was used, together with the varnish on the edges of the plate, may be removed with benzole and the plate is then cleaned with Bon Ami, after which it is rinsed in hot water and dried and is then ready for printing.

Great control over the finished result is possible through variations in the etching baths, for, as has already been indicated, a greater number of baths gives greater contrast, and if a soft result is desired etching may be commenced in a weaker bath than 45°, so that the number of baths is shortened.

If the resist is too dense it may be that the weakest bath will not penetrate the thickest portions of the resist and in that case the 33° solution may be diluted still further.

Printing.—The ink used for printing is that regularly supplied for photogravure work and may be of any desired color. It will have greater brilliance and richness if freshly ground, but for all practical purposes it will work satisfactorily if purchased in a collapsible metal tube from which the required

amount may be squeezed as it is needed. Boiled linseed oil may be used for thinning the ink, which should ordinarily, when ready for use, have such consistency that when a small portion is lifted on the palette knife it can be prevented from falling off only by turning the knife around. A stiff ink will give a darker print than a thin one, hence it follows that considerable modification of result is possible through varying the consistency of the ink.

To apply the ink to the plate, a dabber will be required, and this may either be purchased from a dealer in photogravure supplies or may be made as follows: A strip of heavy woolen cloth about six inches wide and perhaps three feet long has V shaped notches cut in one edge every few inches. The cloth is then wound up until the base is three or four inches in diameter, when the end is stitched fast. A cord is then wound around the neck of the dabber, the final shape of the instrument somewhat resembling that of a pestle. The base of the dabber may be sliced off with a sharp knife until it is even, and a piece of the same cloth is stretched over it and carried up the sides, being stitched in place. With continued use this covering will become stiff with old ink and may be replaced when necessary.

The ink is spread in a film on a sheet of glass or a palette and the dabber is pressed into it several times to insure its being thoroughly covered with the ink. The plate is then warmed over a gas flame until it is about as warm as the hand can bear and the dabber

is worked back and forth over the surface with a rocking motion, in all directions, until the depressions in the copper are thoroughly filled with ink. A piece of coarse well-washed muslin about two feet square is then wadded up in the form of a ball and the surface ink is wiped off the plate with it, this being followed by wiping with a finer piece of cloth. The wiping muslin should be folded in such a manner as to present a smooth surface to the plate, and when the plate has been wiped thoroughly with the cloth, wiping is finished with the edge of the hand. Wiping in this manner will leave a slight tint over the entire plate, and should this not be desired the hand may be rubbed on a cake of Bon Ami and lightly wiped with a cloth and then be passed over the plate, when the surface ink is thoroughly removed and the plate yields what is called a "natural" print. After wiping, the margins of the plate may be cleaned with a piece of chamois folded over the finger, and the plate is ready for printing. It will be found that the plate has become cool by this time and will give a darker print than if it is kept warm during wiping, the ink being thinner when warm, so that more is removed by the cloth. The use of a soft rag, greater pressure, or slow wiping will give a lighter print than the reverse treatment, and considerable modification is possible by varying the treatment in these respects.

For printing, the etching press is advised, although if it is not desired to spend the amount of

money necessary for such a piece of apparatus, a clothes-wringer or a bromoil transfer press may be used, but it will not be possible to make such large prints with this as with the regular press. The etching press is furnished with a metal bed-plate which travels between two rollers, and if a clothes wringer is employed it will be necessary to have a flat piece of stout wood or metal on which to rest the plate during its passage between the rollers. If the etching press is used the plate is laid on a sheet of zinc or paper which rests on the bed-plate, the paper to be printed on is placed on the plate and several pieces of etcher's blanket or of upholsterers' felt are laid over the paper. The screws of the press are then turned down to the proper point and the press is rotated by means of the handle. When the plate has passed through the rolls the blankets are lifted and the paper may be removed from the plate. It is impossible to give any definite idea as to the pressure required, but it should, roughly speaking, be so great that considerable force must be exerted on the handles of the press in order to rotate the rolls. Greater pressure or the use of more blankets will give a darker print by forcing the paper farther into the depressions of the copper. It will probably be found that the first print is unsatisfactory, owing to the plate not having taken the ink perfectly, and a second proof should always be pulled before deciding on any variations of treatment. If the plate gives too dark a print an improvement may be made by

the use of a thinner ink in addition to the methods given in the previous paragraph, and, as stated, a stiffer ink will give darker prints, so it will be apparent that great variations are possible.

Many different papers may be used for printing and the worker is advised to obtain a selection and experiment with them. Practically all papers, however, must be used in a damp state and this may be attained by soaking them in water, then placing two or three sheets between blotters and running them through the press, the excess of water being thus removed, or, if preferred, each sheet may be dipped quickly into water, the sheets being stacked and placed under pressure for several hours.

MODIFICATIONS.—If the plate is to be strengthened as a whole a printer's roller may be used to apply what is known as "finishing ink." This ink may either be bought or be made up as follows, this formula being taken from Herbert Denison's "Treatise on Photogravure":

Asphaltum	1¼ ounces	35 grams
White wax	3 ounces	85 grams
Stearine	3¼ ounces	92 grams
Spermaceti	7 ounces	200 grams

The asphaltum is melted in a double boiler and the other ingredients are added in turn with constant stirring. When cool it will be stiff and may be thinned with turpentine for use. A small quantity is placed on a sheet of glass, the roller is passed over it several times in different directions until evenly covered with the ink, and is then passed over a clean

sheet of glass until only a very thin film of ink remains. The roller is then passed lightly back and forth in different directions over the cleaned copper plate until the surface is lightly charged with the ink. If it is desired to leave the high lights in their original condition, strengthening the half-tones and the shadows, a little more of the ink may be taken up on the roller and applied to the plate, when the shallowest depressions will be filled with the ink and will not be affected by the application of the etching bath. If the high lights and half-tones are to be left unchanged and the shadows strengthened, still more of the ink may be applied, so that the depressions slightly deeper than those in the lights are filled with the ink. After inking, the plate is thickly dusted with asphaltum powder and that which does not adhere to the ink is brushed off with a soft brush. The plate is then heated until the asphaltum becomes incorporated with the ink, the appearance of the plate being distinctly changed at this point. When cool the back and edges of the plate are protected with asphaltum varnish and the plate is re-etched for the desired length of time in a medium strength bath, afterward being cleaned and printed as before.

It is also possible to lay a ground on the cleaned copper plate in the dusting box and set it by heating, after which a weak solution of perchloride of iron may be applied to such portions as it is desired to strengthen, by means of a soft camel-hair brush. The plate should be rinsed from time to time and dried

with a clean cloth or there is danger of the mordant spreading where it is not desired. It is also possible to lighten areas by rubbing down the hills of copper with a burnisher or to darken portions by etching with a needle. These methods, however, are not recommended, since the handwork is very likely to be apparent, and it is decidedly preferable to make necessary modifications on the original negative or on the transparency, even though this may necessitate etching a new plate.

Evidently, it is possible to make multiple prints in photogravure, by inking the plate and running the print through the press a second time. Some method of registration must be used, and this may conveniently take the form of pencil marks or scratches on the zinc or paper underlying the plate, a line being run around the copper plate and marks being made at the corners of the printing paper. Of course, the several printings may be in different colors, as in carbon and gum, and it is possible to make photogravures in full color by printing from a set of plates made from a set of three-color negatives, though this requires a high degree of skill, combined with very careful manipulation.

ROTOGRAVURE.—Rotogravure is of only academic interest to the average amateur, since the cost of the necessary plant is very great, and the process is useful only when large editions are to be printed. As a matter of general interest, however, we may say that it differs from flat-bed hand-proofed photogravure in

that the screen is always used, and that the resist is transferred to and developed on a copper cylinder, which is then etched in the standard manner. Prints from this cylinder are made on a continuous roll of paper, using a rotary press; the cylinder is inked by dipping, as it rotates, into a bath of ink which is much thinner than that used in hand-proofing, and it is wiped by passing continuously under a sharp steel blade known as the "doctor," which scrapes the excess ink from the surface of the copper.

PART IV

COLOR

CHAPTER XVIII

Desirability of Color in Photography

Almost since the first discovery of photography scientists have been working to develop some method which would permit of reproducing not only the gradations of natural objects but also the colors, and considerable success has crowned their efforts, in that methods of color photography have become commercially practical. Up to about 1907 there had been discovered several methods which permit of fairly accurate reproduction of colors, but color photography remained a laboratory experiment, or at least required laboratory apparatus and very careful work, until the introduction of the autochrome plate by Messrs. Lumière. Since that time several plates and films more or less resembling the autochrome in general character have been placed on the market, and various other processes, old in principle, have been developed in detail and standardized so as to make it possible for the advanced amateur to reproduce with a reasonable degree of accuracy the colors of nature, either in the form of transparencies or as prints on paper.

There can be no question as to the scientific value of these processes, since they render possible a per-

fect record of many objects of the highest interest, scientists hitherto having been obliged to rely on the comparatively laborious and inaccurate method of hand coloring, so that to the botanist, the zoölogist, the pathologist and to many other workers in scientific fields color photography renders inestimable assistance, as well as to the commercial worker and the advertiser. So far as the artist is concerned, however, the value of color photography is more or less doubtful, and many arguments are advanced against its use in this field. The writer has at various times made a great many color photographs and, like nearly every photographer, was very enthusiastic over the process on his first introduction to it, but after making perhaps two hundred or three hundred color photographs he found that, the novelty wearing off, the results failed to interest him. In the search for a reason for this condition the writer has come to a very definite conclusion, that in the present state of the art the use of color is not desirable so far as pictorial work is concerned.

Some years ago, in conversation with two well-known painters, the writer said: "How much do you feel that photography loses by being unable to reproduce colors?" One of the painters answered, "I do not feel that it loses anything. If you examine the black-and-white reproductions of the works of the great masters you will find that in many cases the black-and-white version is more interesting than the original, and this is true even of the works of the

THE CONNECTICUT RIVER
BY W. E. MACNAUGHTAN
From a Platinum Print

Venetians, such as Titian," and turning to the other painter, he asked: "Isn't that so?" The other replied: "Absolutely; and if Titian's color couldn't make a thing interesting, nobody's could." Here, then, were two painters, both of them able men, both of them familiar with the best works in their medium, and both of them accustomed to work in color, who felt that a black-and-white art could, other things being equal, be quite as interesting and as valuable as a color art. The average layman is actually thrilled by the sight of a photograph in color, as witness the immense sale in this country of hand-colored prints, and the extensive use of color in advertising, so it must be apparent that the layman and the artist are pleased by entirely different aspects of art. In this connection it is interesting to note that in his book, Colour Photography in Practice, D. A. Spencer, who is a Past President of the R. P. S., plant manager of Colour Photographs Ltd., of London, and an expert worker in the field of color, says definitely that although it is not possible to predict what may happen in the future, up to the present time color photography cannot be regarded as a medium of art expression.

To determine the cause of the different feeling which exists between laymen and artists, it may be well to consider first the appeal made by different forms of art, and it will be found that every art possesses in varying proportions an admixture of both sensuous and intellectual appeal. Thus, the appeal

of music is almost entirely to the senses, the intellectual part being so slight as to be not worth considering; that of prose writing is almost entirely intellectual; that of poetry may be composed of intellectual and sensuous constituents in almost any proportion; that of architecture is almost exclusively intellectual, and so on. It is of course apparent that, whereas an intellectual appeal is to the logical faculties, a sensuous one is to the physical portion of the individual; that is, certain nerves respond to certain stimuli, thus affecting in greater or less degree the entire nervous system. It is well known that certain classes of music may stimulate the hearers to almost entire self-forgetfulness, inducing either tears or great exaltation, but it is not so well known that color possesses in lesser degree the same power. It has been found that the warmer colors, such as red, orange and yellow, stimulate the nervous system very markedly through the action on the optic nerve, so that no neurologist would permit a patient to remain in a room finished in red, whereas the cooler colors are distinctly quieting to the nervous system. Hence it follows that the combination of different colors in their suitable proportions may produce a sensuous excitement or a sensuous calm resembling that aroused by music. It seems clear, then, that the function of color in art is to heighten the effect by producing in the spectator a nervous condition which renders him more receptive to the idea which the artist wishes to convey, and that when

the artist wishes to appeal solely or principally to the intellectual faculties, he will refrain in great measure from the use of color, and will certainly employ only subdued colors. Examination of the works of those artists who are noted for their psychic insight, such as Rembrandt and Velazquez, shows that these men employed color to a very limited extent, their work being conspicuous for the use of secondary and tertiary colors, almost to the exclusion of primaries.

Most persons think of photography as being closely allied to painting, etching, and the other graphic arts, but as a matter of fact it is more nearly akin to sculpture than to any other form of art expression. The essential characteristics of photography are its ability to render with accuracy the outlines of objects, and to reproduce with fidelity the gradations of light on surfaces, this being precisely the manner in which the sculptor works. It is true, of course, that the sculptor uses actual forms, but these forms become visible to us only by reason of the light that is reflected from them. The painter and the etcher *suggest* this reflected light, but the photographer *reproduces* it. Therefore a photograph shows any natural object precisely as the sculptor would do, except that it shows only one view of it, whereas the sculptor would show many views; or, to put it differently, the sculptor shows the object as the photographer would do if he walked around it, taking pictures on all sides. Now, with the exception of architecture, sculpture is the most highly in-

tellectual of art mediums, and color is out of place in it; it is true that the Greeks did color their statues, in the effort to intensify their appeal, but the more highly developed taste finds that this is inadvisable, preferring to leave the surface uncolored and to develop the textural quality of the material, whether marble, granite, bronze, or other substance. Therefore, since photography is a highly intellectual form of art, closely related to sculpture, the conclusion is that it will do better to ignore color, but at the same time to give due attention to the surface texture of the printing medium; this suggests one reason why the more thoughtful workers prefer such esthetically beautiful mediums as palladium, gum, Fresson, and bromoil transfer to the commonplace and inherently uninteresting bromide and chlorobromide papers.

Since photography is capable of reproducing more perfectly than any other art the outlines and gradations of natural objects, and since it reproduces colors with comparative difficulty, it would seem that the worker with the camera is particularly favored if he desires to produce a result which shall appeal to the logical faculties rather than to the senses, and this serves to indicate the difference of opinion existing between artists and laymen as to the value of color in photography, for the artist is necessarily trained to observe and to think, whereas the average individual does neither. Many persons will be inclined to question this statement as to the failure of

the average person to observe his surroundings and to employ his logical faculties, but investigation shows that it is quite justified. Confining the appeal of any form of expression to the intellectual value of course does not preclude an emotional effect, but it does in general restrict this appeal to the more highly educated and more intelligent observer.

The photographer who wishes to work in color is, generally speaking, limited as to the ability to produce various effects, since he cannot modify the internal relationship of his colors with the same ease that the painter can, and it therefore seems a mistake for a worker whose desire is to effect a sensuous stimulus to employ the camera; but the possibilities of appealing to the logical faculties by means of photography seem almost unlimited; the writer, therefore, feels that color photography does not merit serious consideration by the pictorial worker.

CHAPTER XIX

Color Photography in Practice

It is not the writer's intention to give, in this chapter, the technical details of the various methods which are employed to produce photographs in color; to do so would expand this volume to an excessive size, and in addition would be superfluous, these details being readily obtainable from the manufacturers of the materials. The purpose is rather to give a description of the fundamental characteristics of each process, together with some discussion of the advantages and disadvantages of each.

Broadly speaking, there are two basic methods in use. In the first, commonly referred to as the screen-plate method, which includes the Lumière Filmcolor, Dufaycolor, and Agfa films and the Finlay plate, a specially prepared film or plate is used, the result is a transparency, and, except in the case of the Finlay plate, duplication is not readily feasible, a separate exposure being required for each picture. In the second method, generally spoken of as the three-color method, color-separation negatives are made, and prints from these are so combined as to give a print on paper in the colors of the original subject, duplication being comparatively easy. This

includes the three-color carbon and carbro processes, Wash-Off Relief, Chromatone, Belcolor, and various lesser-known mediums.

Screen-Plate Transparencies.—All photographic color processes depend on the fact that all natural colors can be reproduced by the mixture, in proper proportions, of the three primary colors, violet, green, and red. The Autochrome process (now called Filmcolor) was the first to be commercially successful, and is typical of the screen-plate process, so we will consider that first.

A number of very fine starch grains are dyed in the three primary colors, red, green, and violet, are mixed in the proper proportions, and are spread on a plate or film, being rolled out under heavy pressure to form a continuous, though irregular, screen. A very thin panchromatic emulsion is coated on this screen, and the exposure is made with the back of the film or plate toward the lens, so that the projected image must pass through the color-screen before reaching the sensitive emulsion. If we consider one particular color it will be easier to follow the theory of the subsequent processes, so we will fix our attention, say, on an area of red in the subject, which occupies perhaps half a square inch on the plate. Each of the colored starch grains acts as a filter, the violet and green absorbing the red rays completely before they reach the sensitive emulsion, the red grains, on the other hand, permitting the red rays to pass freely. Hence it follows that the red

light reflected from the subject affects the sensitive emulsion only directly over the red grains and on development we have a deposit of metallic silver over the red grains, while the silver bromide remains unaffected over the violet and green grains. When development is complete, the plate is immersed in a solution (an acidified potassium bichromate or potassium permanganate) which dissolves metallic silver but does not attack the unreduced haloid salt. The plate is then exposed to light and is again developed, with the result that there is a space of transparent gelatine over each red grain in the area under consideration and an opaque deposit of metallic silver over each violet and green grain, so that on holding the plate up to the light the area in question will appear red by reason of the fact that the red starch grains absorb the violet and green components of white light, permitting only the red rays to pass through. A like result occurs in the case of violet and green objects, and since we have found that secondary and tertiary colors, such as blue, yellow, brown, etc., are made up by a suitable mixture of two or more primaries, it follows that the colored starch grains sift the primaries reflected from natural objects and the appearance of the subject is thus reproduced not only in gradation but also in color.

The Dufaycolor film and Agfa plate resemble the Autochrome, except that in the former the color-screen is regular, being produced by ruling, instead

of being heterogeneous; they vary, otherwise, only in minor details of processing.

In the Finlay process (originally known as the Paget process) the color-screen, which is a regular, ruled screen, and the sensitive emulsion are on different plates, these plates being placed face to face for the exposure. The sensitive plate is then developed and fixed, like any panchromatic plate, positives being made from it by contact printing on other plates, and being bound up in contact with a special "viewing screen," when the colors appear as in the original subject. It will be evident that, unlike the other processes, this allows of any number of duplicates being made from one original exposure.

In the Kodachrome process, the celluloid support is first coated with a red-sensitive emulsion, over which is placed a dyed gelatine coating which acts as a ray-filter, permitting only red light to pass through it. Over this is placed a green-sensitive emulsion, similarly screened, and on this a violet-sensitive emulsion. On exposure, each element of the incident light affects the emulsion which is sensitive to it, so that when the film is developed each element is represented by a deposit of metallic silver. This negative is then reversed, as with the Agfa and Filmcolor, the result being a positive in which the colors complementary to each of the primary elements are represented by a deposit of metallic silver in the corresponding film layer. This positive is then bleached, the images in the successive layers being

produced in color by means of dye-coupling. That is, the silver is re-developed with a developer the oxidation products of which combine with organic substances in the layers to produce insoluble dyes, the metallic silver being afterward removed. The final result is a dye transparency in which the colors repose in different layers of film, instead of side by side, as in the other processes.

In accuracy of color rendering, there is little choice among these processes; properly handled, all are excellent. In brilliance, there is a very great difference, Kodachrome being far superior to the others, as is at once realized when we consider that in the other processes any light which is not used in a given area, to produce the desired color in that area, is blocked out by an opaque deposit of silver, whereas in Kodachrome this does not occur. There is also a wide difference in the difficulty of processing. Filmcolor, Agfa, and Dufaycolor are so simple that they can be processed by any tyro who can follow very easy instructions; the Finlay process demands about the degree of technical skill possessed by an advanced amateur; and Kodachrome is so complicated and difficult that the manufacturers do not publish any instructions, but require that the exposed films be returned to them for processing, the cost of this operation being included in the original purchase price. Thus it will be seen that when the photographer wishes to inspect his results at once, it is necessary to use either the Agfa, Dufay,

or Filmcolor processes, but if a delay of from one to two weeks does not matter, he will get more brilliant (though not necessarily more truthful) transparencies with Kodachrome. The absence of a definite screen in Kodachrome also makes it possible to project to a larger size than with the screen-plate processes, though it should be noted, as a matter of academic interest, that the apparent grainlessness of a Kodachrome transparency is not due, as most persons think, to the fact of its being a dye image rather than a metallic one, but to the fact that it is a reversal process. When a film is developed and reversed, the clumping of the grains of the emulsion takes place chiefly in the first development, the grain size in the second development being, so to speak, complementary to that in the first. Hence any reversed film shows less grain than a straight negative on the same emulsion, the granularity of the screen-plate processes being due to the color-screen and not to the sensitive emulsion.

In all of these methods, exposure is critical. Instead of having a latitude of several hundred, or even several thousand, per cent, as may be the case with black and white negatives, the latitude of a color film is seldom over 10%. From this it results that a flat lighting is almost always desirable (to reduce the scale of gradation in the subject) and that some exact means for determining the exposure must be used. Errors of exposure seriously impair the color rendering, under-exposure tending to ex-

aggerate the blue element, whereas over-exposure emphasizes the warm colors.

Numerous methods have been developed for making color photographs on paper, all of them depending on the use of color-separation negatives. That is, three negatives are made under suitable filters, each one recording one of the primary elements of white light; and from these negatives prints are made in the colors respectively complementary to the taking colors, these prints being superposed to produce a finished result in full color.

THREE-COLOR SEPARATION NEGATIVES.—There are several methods of making the required set of color-separation negatives, the simplest being the use of the Tripak. This consists of three films which are bound up together, sandwich-fashion, each film carrying not only a sensitive emulsion but also a layer of gelatine which is dyed so as to function as a ray-filter for the film or films below it. This pack is placed in an ordinary holder and exposed in any camera that is adapted to use cut films, when the film nearest the lens records the violet component of the projected image, the second records the green component, and the third the red component. The pack is then cut apart and the three films are developed, furnishing (if exposure and development have been correct) a satisfactory set of three-color separation negatives from which prints can be made by any of the standard methods. This method is very easy and simple, and requires no special camera, the

sole drawback to it being that it will not give fine definition in the larger sizes; the mechanical separation of the films, together with irradiation (that is, the spreading of light within the emulsion) causes a perceptible softening of the image. It must be admitted, though, that this diffusion may in certain circumstances be definitely pleasing rather than the reverse.

When dealing with stationary subjects, such as still-life, or a landscape on a windless day, a set of sharply defined color-separation negatives may be made with an ordinary camera by using three films in different holders, changing the holders for successive exposures; in this case the requisite ray-filters may be placed either on the lens in the usual manner, or, in order to shorten the total time of exposure, directly in front of the films in the holders. The disadvantage of this method is that the time required to change film-holders precludes the photographing of objects in motion, and makes portraiture difficult; however, by placing his sitters in a comfortable position, the writer has made successful portraits with three successive exposures, as outlined. The total exposure time in this method is sometimes shortened by using a special repeating back on the camera.

When sharp definition together with brief exposure is demanded, it is necessary to use a "one-shot," or "beam-splitter" camera. In this instrument two film-holders are used, one being located at the

back of the camera in the conventional manner, the other at one side of the camera, at right angles to the first. The first holder carries a Bipak consisting of a green-record and a red-record film placed face to face, the violet-record film being in the second holder. A "sputtered" mirror, so adjusted as to reflect the proper proportion of the incident light and to transmit the remainder, is placed at an angle of 45° in the path of the beam from the lens, thus splitting the beam into two parts, one of which is reflected to the blue-record film, while the second passes on to the Bipak. Brief exposures and very accurate results are possible by this method, the chief drawbacks being the high initial cost and the delicacy of adjustment necessary in the camera, which, moreover, is relatively bulky. Sometimes three separate holders and two mirrors are used, the beam being split into three parts, but little if anything is gained by this method, which still further intensifies the disadvantages mentioned.

A further method, which has the advantages of permitting short exposures and a small camera in the field, is to make the original photograph on a screen-plate film or plate, and from this to make a set of color-separation negatives at leisure, in a copying camera. The only disadvantage of this plan is the initial cost involved, a copying camera being rather expensive, though less so than the beam-splitter.

PRINTING FROM THREE-COLOR SEPARATION NEGATIVES—CARBON AND CARBRO.—There are several methods of making the finished print in color from a set of color-separation negatives, probably the simplest being the carbon process, using double transfer. Since the thin portions of each negative represent the absence of the color complementary to that recorded, it is obvious that each negative will be printed in the secondary color complementary to the taking color: that is, the violet-sensation negative will be printed in yellow (green+red), the green-sensation one in magenta (violet+red), and the red-sensation one in blue (green+violet). The trichrome tissues are used, the three separate prints being transferred to, and developed on, a transparent temporary support. They are then transferred, one by one, to a final white, opaque support (usually paper) registration being effected by visual inspection.

Carbro is also used for this purpose, the carbon prints being made in the standard manner from three bromide prints which have been made from the separation negatives. The transfer method is used, to facilitate registration, the mechanical part of the process being the same as in carbon.

The advantage of carbro over carbon is the same as in black-and-white work, namely, that large prints may be made from small negatives. Carbon, however, has the advantage of escaping several rather tricky and uncertain chemical operations. It is practically impossible to work with any surety and pre-

cision in either method unless the workroom is air-conditioned for both temperature and humidity.

Chromatone.—In Chromatone the manufacturers supply an enlarging film consisting of a chlorobromide emulsion in a stripping collodion. Prints or enlargements are made in the usual manner on this material from the separation negatives, being then toned to the proper colors by means of chemical toners which transform the silver images to colored compounds of silver. The films are then stripped from the paper and superposed in register on a final support paper, being cemented in optical contact.

Wash-Off Relief.—For this the manufacturers supply an enlarging film consisting of a soft gelatine-chlorobromide emulsion on a transparent celluloid support, prints or enlargements being made on this in the usual manner, except that they are exposed through the support, so that the silver deposit lies in the stratum of gelatine next the film. After developing and fixing, the prints are bleached in a bleacher similar to that used in bromoil, the effect being to tan the gelatine in proportion to the amount of silver it contains. The prints are then washed in warm water, which removes the untanned gelatine, leaving a relief the varying thicknesses of which correspond to the amounts of silver in the different portions of the prints. These reliefs are then dyed in suitable aniline dyes, and are squeegeed, one after the other, into registered contact

with a special gelatine-coated final support, which absorbs the dyes from the three color prints to form the final three-color image.

Other Methods.—There are various other less widely known color printing processes, such as Belcolor, Duxochrome, etc. In Belcolor, the material consists of soft gelatine films carrying suitable pigments and coated on a transparent support. These are sensitized in a solution of potassium bichromate, and printed by contact through the support, being afterward developed in warm water and superposed in optical contact or transferred to a paper support as is done with carbon. Duxochrome is practically the same as Wash-Off Relief, except that the dyes are incorporated in the gelatine emulsion, thus avoiding the necessity for a separate dyeing. There are also various methods which depend on the fact that certain aniline dyes are bleached and disappear when exposed to light under a negative, but can be stabilized by chemical treatment. And, of course, there are the photo-mechanical processes, such as half-tone and photogravure, in which three printing plates, either relief or intaglio, are made from the negatives and are successively printed in colored inks.

General Remarks.—In general, it may be said that although the transparency processes are (except for the processing of Kodachrome) well within the manipulative ability of any ordinarily intelligent and careful amateur, the three-color processes re-

quire a degree of technical skill which is far beyond that possessed by most amateurs. And although the author would hesitate to say that satisfactory color prints cannot be produced by these various processes, it is a fact that except for prints made in carbon, carbro or photo-mechanically, he has never seen any which he considered a thoroughly good rendering of natural color; as a rule, the highlights are weak, the shadows are muddy, or the colors in general are harsh and unpleasant; he has seen a great number which he considered moderately good, but none that he would call very good. In one of his stories, Rex Beach said: "The difference between an amateur and a professional athlete is that an amateur *wants* to win, but a professional's *got* to win." And it is significant that up to the time of writing, carbro, with all its difficulties, remains the favorite process of the professional three-color workers.

THREE-COLOR GUM.—If a set of three-color separation negatives has been made, by any of the methods outlined above, it is possible to print from these in the gum-pigment process, making a multiple print in the suitable secondary colors, so that the final result gives a more or less correct representation of the original subject, the degree of approximation depending of course on the worker's skill and his eye for color.

This method has certain advantages and disadvantages as compared to other methods of color printing. Admittedly, it is much more laborious,

and requires a greater degree of technical skill than any other; but against these disadvantages may be set the facts that since almost any paper can be used as the support for a gum print, it is possible to secure an interesting surface texture in the final result, instead of the rather uninteresting smooth texture that is characteristic of other processes; that the objectionable gloss of other color prints can be almost if not quite entirely avoided; and that, since a gum print is more susceptible of brush development than other mediums, the worker can introduce local variations of color which are not otherwise possible, so he is not restricted to a literal, mechanical reproduction of the appearance of the subject.

Anyone who plans to work in this technique will do well to make a few three-color prints in carbon from his separation negatives, before undertaking the gum process, since he will thus gain an idea of the pigments which will best render the desired effect; obviously, the printing colors must be correctly matched with reference to the taking screens. In all probability, enlarged negatives will be used for the gum print, but it is not necessary to make the carbon prints from these; the small originals will serve perfectly for experiment, since the larger ones can be balanced exactly with these.

For reproduction work in color the most highly corrected lenses are used, but for pictorial work, where a slight diffusion of outlines does no harm, these are not necessary. The writer has even used a

Struss lens for three-color work, this objective possessing, as has already been noted, all possible optical errors, and though such a lens would naturally be expected to give color fringes—since the diffusion depends largely on chromatic aberration—in practice it does not seem to do so, merely softening the outlines in a rather pleasing manner.

Similarly, in reproduction work the highest grade of optically flat glass is used for the filters, but in pictorial work the much cheaper grade known as "B" glass is perfectly satisfactory. Indeed, the writer has made satisfactory three-color separation negatives with gelatine film filters which were not even cemented in glass, but were merely bound up between lantern-slide cover glasses, for protection.

In order to obtain the proper gradations and depth it may be necessary to print twice or more in each color, and it will often be found that a light printing of black from a fourth negative made with a corrective filter will be helpful, since, although the three printings of blue, yellow, and magenta should theoretically give a black where such existed in the original subject, practically they will not do so, owing to the impossibility of obtaining theoretically perfect pigments.

The three-color gum process is an exceedingly laborious one and in the writer's opinion the result does not repay the effort expended, though the worker who desires color prints and is willing to give the time necessary to their production will probably

find this process more satisfactory from an artistic standpoint than any other. Obviously, too, the bromoil transfer process may be used for the same purpose.

Multi-Color Gum Printing.—Some workers endeavor to produce striking effects by printing in arbitrarily chosen colors from a single negative, shading portions of the negative while printing one color and the remainder of the negative while printing the other colors, or removing the first color from certain areas of the print by scrubbing with a stiff brush and allowing these portions to print in the second or third color, these in turn being removed from areas where they are not desired. The writer has never seen a print of this sort which possessed any artistic merit whatever or could be considered anything except thoroughly unsatisfactory.

PART V

MISCELLANEOUS

CHAPTER XX

Photography by Artificial Light

Twenty-five years ago, the photographer who wished, or was obliged, to work by artificial light, had at his command only incandescent gas or carbon filament electric lamps, both of which were relatively slow and inconvenient: the carbon arc lamp, which was dirty and inconvenient: the mercury vapor lamp, which was inconvenient and which gave utterly false color values: or, if short exposures were required, flash powder, which was not only dirty and inconvenient, but also dangerous. But with the development of the fast panchromatic emulsions and the tungsten filament lamp, and the invention of the foil-filled flash lamp, photography, and even high-speed photography of moving objects, has become a matter of the greatest simplicity, well within the reach of the average amateur. There are three simple forms of artificial illuminant available, which we will consider in turn.

THE TUNGSTEN FILAMENT LAMP.—This is the ordinary incandescent lamp of commerce, manufactured in sizes ranging from 10-watt to 50,000-watt, sold under the trade name of Mazda, and generally used in the 60-watt or 100-watt size for home

illumination. With a fast panchromatic film, a lens working at F/4.5, and a single 100-watt bulb in a suitable reflector at six feet or so distance from the sitter, satisfactory portraits can be made with exposures of from 1/10 second to 1 second, and if a supplementary lamp or reflector is used to lighten the shadows, these times can be considerably shortened.

The larger sizes of Mazda lamp are suitable only for studio illumination, since they require a special socket, and draw too heavy a current for the ordinary house wiring, but when used either as flood lamps or as spot-lights, a suitably balanced illumination permits exposures as brief as 1/50 to 1/100 second, or with ultra-fast lenses, even less.

For the sake of negative quality and artistic effect, these lamps should generally be used with some sort of diffusing screen, to avoid harsh cast shadows. Such a screen may be improvised from tracing paper or tracing cloth, from cheesecloth, or from any similar material; in an emergency, the writer has obtained satisfactory diffusion by draping a handkerchief over the reflector. Such a diffuser of course cuts down the light materially, and a more satisfactory kind is made of spun glass; this last has the defect of being brittle, and requiring careful handling, but it is very efficient.

The Photoflood Lamp.—This is merely an ordinary tungsten filament lamp, so designed that the filament would run at normal temperature on a

voltage of about 65. When operated at the ordinary house voltage of 110 to 115, the filament becomes much hotter than normal, with the result that the intensity of illumination is greatly increased. There are two sizes of these lamps, the smaller fitting any ordinary socket, and giving a light about equivalent to a 750-watt Mazda; the larger requires a special adapter to fit it to the socket, and is about on a par with a 1500-watt Mazda. Of course the life of the lamp is greatly shortened by this over-running, being from two to ten hours, but it is possible to buy a stand with two sockets, two reflectors, and a series-parallel switch, so that the lamps may be burned in series, at normal voltage, while arranging the picture and focussing, being thrown into parallel and burned at the higher voltage only during the few moments required for the exposure, this being a very economical way of using the lamps.

With two of the larger size lamps in reflectors (using one to relieve the shadows), a lens working at F/4.5, and a fast panchromatic film, exposures of 1/200 second or less are entirely possible. When this arrangement is used, color pictures on Kodachrome film may be made with exposures of the general order of 1/25 second; if Dufaycolor or Filmcolor is employed, exposures of 1/10 to 1/5 second are required. Thus it becomes possible, with a fast lens, to make perfectly satisfactory indoor movies at night in color, as well as color stills.

It is interesting to note that the light from these

lamps tends more toward the red end of the spectrum than is the case with daylight, wherefore a very acceptable black and white rendering of the values is obtained with a panchromatic film without a filter, though for absolutely correct color rendering a filter must be used.

The Photoflash Lamp.—This is a vacuum bulb similar to a Mazda, using any ordinary socket, but in addition to a very fine fuse wire the bulb contains a mass of crumpled aluminum foil. When an electric current passes through the wire, this heats up instantly and burns out, touching off the foil, which burns with an intensely brilliant flash of about 1/50 second duration; obviously, one lamp is good for only one exposure. These lamps also come in several sizes, and may be operated either on the house circuit or in a hand-held reflector using two small dry batteries; reflectors are made to take either single lamps or groups of one, two, or three bulbs. Using a fast panchromatic film, a lens working at F/11, and one of the smaller bulbs six feet from the sitter, the writer has obtained perfectly satisfactory portraits of a subject seated at a dark mahogany desk, the detail in the shadows of the wood being admirably rendered.

The Synchronized Photoflash.—The duration of the flash in the flash bulb is about 1/50 second, and for moving objects which do not require exposures shorter than this, excellent results may be secured by setting the shutter on Time or Bulb,

opening it and firing the flash, then closing the shutter. The curve representing the rise and fall of the illumination is very abrupt, and when extremely short exposures are required, as of athletes in motion, it is customary to use an electric equipment attached to the camera and synchronized with the flash, so that the shutter is magnetically tripped at the peak of the illumination, this peak lasting about 1/150 second. By this means, if several lamps are used, it is possible to get fully illuminated photographs with exposures as brief as 1/1200 second. This synchronized flash is often employed by news photographers even in daylight, since it does away with all uncertainty of exposure, and the supplementary illumination afforded by the daylight does no harm—indeed, it often improves the result, and some very pleasing effects have been obtained when the relative intensities of the daylight and the flash have been properly balanced.

It should be noted that up to the time of writing it has not been possible to synchronize the larger sizes of focal plane shutter with a flash bulb; $2\frac{1}{4} \times 3\frac{1}{4}$ is the largest that has been successfully adjusted in this manner, and for negatives larger than this a between-lens shutter must be used.

The Artistic Value of Short Exposures.—Although the very brief exposures that are possible with the intense illuminations described have a decided value in news and record work, the writer does not feel that their pictorial merit is, in general,

very great. There are two reasons for this. In the first place, the negative quality obtained in portrait and genre work is not so good under a powerful illumination as it is with a softer lighting; the strong light burns up, so to speak, the extremely delicate gradations, so that they are not rendered in the negative. For this reason, the writer prefers to use a weaker light for portraits, generally choosing one which requires about one second exposure at F/4.5. Some persons may object that it is impossible to make portraits of children with an exposure of a full second, but such is not the case. The writer has made hundreds of children's portraits with exposures even longer than this; it is merely a question of watching for an opportunity, and making the exposure while the child's attention is momentarily concentrated on some object or some action. And it may be added that the pose and expression thus obtained are usually more natural and characteristic than when the portrait is caught "on the fly." In this connection it is interesting to note that the photograph used as the frontispiece of this book was made entirely by the light of the two candles included, with no reflectors or supplementary illumination whatever.

This brings us to another matter—the artistic value of the instantaneous rendering of action. When rapid motion is involved, as in the case of athletes in action, the human eye does not see the complete motion, but only the position of the limbs or other

moving members at their periods of rest, when the direction of their motion changes. For this reason, the painter or draftsman, when representing either human or other animals in action, does not attempt to show the intermediate stages of the action, but depicts only the points of arrested motion; in other words, he does not analyze the action, but synthesizes it. Since two or more limbs do not always reach a point of rest at the same instant of time, it follows that the draftsman's representation is often untrue to fact; further, analyzing a fluent action by examining the individual frames of a motion-picture frequently proves that the drawing of the action is not only false to nature but represents a pose which is actually impossible. But the artist, in contradistinction to the reporter, is not concerned to tell things as they actually occur; his purpose is to represent them so that the representation seems true, without actually being so; in all art it is the impression, rather than the fact, that counts. And it is largely for this reason that fluent motion seems to us graceful, whereas an instantaneous photograph showing an arrested phase of it seldom is; one of the best possible examples is in the case of women tennis players, who in action give an impression of grace and beauty, but in the newspaper photographs are distinguished chiefly by extreme awkwardness and ugliness.

So if we examine the works of the great painters and sculptors we shall find that when they represent

action, as in Millet's "The Sower," or the Niké of Samothrace, or "The Punishment of Dirce," the motion is either an arrested phase, or the synthesis of several arrested phases. It is for this reason that the writer does not care for the snapshot method of representation (especially in portraiture) but prefers to wait the opportunity offered when the subject spontaneously reaches a point of arrested motion and permits a relatively long exposure. This method is applicable to many subjects which are generally believed to demand brief exposures; the writer has made a great many portraits of children under five years old with exposures of three or four seconds; street scenes at 1/10 to 1/5 second; and even a diver, if caught at the top of his (or more likely, her) flight can be captured with 1/5 second and incidentally will give a more pleasing picture than if caught halfway down the drop with 1/200 second. Short exposures showing arrested motion are for the newspaper photographer, not for the artist with the camera. D. O. Hill's magnificent portraits, as yet unsurpassed by any photographer, were made, owing to the primitive character of his apparatus, with exposures of 5 or 6 *minutes*, in direct sunlight.

CHAPTER XXI

Motion-Picture Photography

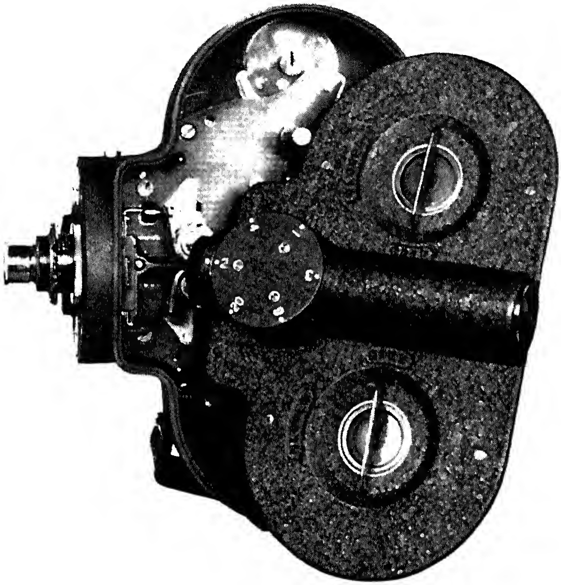
The term which we frequently hear applied to motion pictures, that is, moving pictures, is a misnomer, since the picture seen on the screen by the observer does not actually move but is as stationary as any print may be. The illusion of motion is due to a phenomenon known as the persistence of vision, the result of which is that an object which is observed for a small fraction of time and then is suddenly removed from the spectator's range of vision apparently continues to be seen for an appreciable time after it is removed, the retinal image not fading at once. In motion-picture work an object in motion is photographed and a fraction of a second later is photographed again, when it obviously will have moved through a short space. A fraction of a second later it is again photographed in a succeeding phase of motion, and so on for as long as may be necessary to show the complete movement. From this series of negatives, transparencies are made on a long strip of film and are projected in an interrupted sequence on the screen. The observer fails to recognize the obscuring of one phase of the motion during the time that another is being brought on the screen,

and thus an illusion of continuous motion is produced.

In practice this result is attained as follows: A long strip of film is so arranged that it may be wound past the lens with an intermittent motion. During the period of rest the shutter is opened and the exposure made, the shutter is then closed and the film is jerked forward a short distance, when the shutter is opened again and another exposure is made and so on for as long as it may be desired to continue the operation, within, of course, the limits placed by the amount of film which it is possible to arrange in the magazine of the camera. Figure 45 shows a typical modern amateur motion-picture camera. In the body of the camera are placed two magazines, the upper one carrying the unexposed film. From this magazine the film is carried through a velvet-lined slit, which of course is light-tight. From this it passes over a sprocket, being formed into a loop the purpose of which is to insure flexibility of motion and to prevent dragging of the film. The teeth in the sprocket engage in perforations along the edges of the film, as do also claws which operate by a cam, the claws serving to drag the film forward during the period when the shutter is closed. The film passes over a small plate which insures contact between the film and the gate, the latter being the opening behind the lens through which the exposure is made. After leaving the gate the film is formed into a second loop and passes over another sprocket,

By courtesy of Bell and Howell Company

FIG. 45.—16 mm. MOTION PICTURE CAMERA



By courtesy of Bell and Howell Company

FIG. 46.—INTERIOR OF MOTION PICTURE CAMERA

whence it is wound into the magazine for exposed film at the bottom of the camera. The shutter is in the form of a rotating wheel part of which has been cut away so that it alternately opens and closes the lens.

Practically all of the present-day motion-picture cameras are motor-driven, the power being furnished either by an electric motor or by a spring-actuated clockwork. The minimum speed at which a satisfactory impression of ordinary motion can be given is 16 exposures per second, but for special purposes many cameras are arranged to give speeds ranging from 8 to 64 exposures per second. It has been found that when sound is to be reproduced, the satisfactory minimum is 24 exposures per second, and most cameras and projectors are normally geared to that speed, which also gives a more pleasing representation of motion. The normal exposure is 1/30 second, and is usually constant, variations in light intensity being taken care of by changing the aperture of the lens.

Sound apparatus is no longer so expensive as to be out of reach of the average amateur, but so rarely does the worker of this sort have any real appreciation of its use and value that it is best left alone except by the rare individual who is willing to devote a great deal of study and effort to the subject. Briefly, it is of two types, the variable density and the variable width. A narrow track at one edge of the film receives a beam of light, the intensity or

the width of this beam being controlled by a microphone and an apparatus somewhat similar to that used in radio broadcasting. This sound track is of course developed simultaneously with the picture, and when the film is printed and projected, light passing through the sound track is modulated and is translated into sound by an apparatus resembling that used in the reception of radio broadcasts.

Motion-picture film is furnished in three standard widths, 35-mm., 16-mm., and 8-mm. The 35-mm. size is that which is used professionally, for theatre projection, and is developed to a negative, from which positive prints are made (usually by contact though sometimes by projection) for final use. The 16-mm. and 8-mm. sizes are for amateur cameras, and are reversible films; that is, the film is developed to a negative, but instead of being fixed and printed, it is reversed to a positive, as is done with a screen-plate transparency, or in making enlarged negatives by reversal, as outlined in Chapter VII. If desired, it can of course be developed, fixed, and printed, as is done with the professional film, or it can be enlarged to 35-mm., but as a rule the amateur does not want more than one positive film, so the reversing process is the one normally used. It is possible for the amateur to process these reversible films, but since the second exposure to light must be controlled in order to obtain satisfactory results, it is generally better to return the film to the manufacturer for processing, the charge for this operation being in-

cluded in the purchase price of the film. The purpose in using a reversible film is partly for the sake of economy, but even more because either contact or projection prints from these small films show excessive grain, whereas when the reversing process is employed the chief clumping of the silver grains takes place in the first development, the final reversed image having a much finer texture than the original one.

Some cameras are so constructed that the exposure covers only one-half of a 16-mm. film; when the entire reel has been run through the camera, it is reversed and run through a second time, the second sequence of exposures being made on the other half of the film. After processing, the film is split lengthwise, and the ends are cemented together, thus giving for projection a positive film 8-mm. wide. This represents an obvious economy of film, and is perfectly satisfactory when a projected image not over four or five feet wide is desired. In other words, for home use the 8-mm. film is suitable; for home or small lecture halls, the 16-mm. is indicated; and for general public exhibition the 35-mm. is practically imperative. Cameras using straight 8-mm. film were built some years ago, but were not very successful, and were withdrawn, being replaced by the system of splitting a 16-mm. film. Recently, however, they have reappeared on the market, some of them in the form of an instrument which will either

take the 8-mm. size or will split the 16-mm., as desired.

It should be noted that all 16-mm. and 8-mm. film is coated on an acetate base (safety) support, therefore the projection of such film does not demand the elaborate safeguards against fire which are necessary when the inflammable nitrate base 35-mm. film is used.

Esthetic Considerations.—The development of motion-picture cameras for amateur work has been so great since this book was first written, their use has become so widespread, and such elaborately detailed instructions have been published by the manufacturers and others, that there would be little point to filling these pages with a repetition of those instructions. Further, the writer feels that, so far as amateur work is concerned, the motion picture hardly falls within the category of pictorial photography, that it cannot be regarded as contributing to the production of works of fine art; wherefore it seems best to devote this chapter largely to a discussion of the esthetics of the motion picture rather than to mere technical instruction.

Twenty years ago, the author stated his belief (in opposition to that of many persons) that the motion picture would never supplant the theater. To-day, in spite of great technical improvements and a vast increase in popularity of the movies, this belief still holds good; the stage still flourishes, and is doing quite as well as at the earlier period. The author has,

however, so far revised his opinion as to feel now that the motion picture is potentially—though far from actually—the greatest of the arts, with the possible exception of architecture. It has several elements of power which are lacking to the other graphic arts; size, motion, sound, a possible stereoscopic effect, and probably, at some future time, realistic color, though it must be admitted that up to the time of writing genuinely good color is possible only in amateur films, the attempts at color which are shown in our movie theaters being hardly more than farcical imitations of the actual thing. With these elements of strength, it is not far-fetched to suppose that the motion picture may at some future date be dominant in the world of graphic arts, even though it may never supplant the other forms of art expression.

But this supremacy can never be attained so long as the movies continue to be frankly aimed at a mental spectator level of twelve years. This low aim is bound up with financial considerations, and these in turn with the popularity of the art; hundreds of millions of dollars have been invested in huge plants; a great army of technical workers is employed; actors and actresses—many of them chosen for superficial beauty or for sex appeal rather than for dramatic ability—are paid ridiculously inflated salaries; and in order to maintain this tremendous industry the box-office receipts must be kept up. And since the general public, to whom the movies must appeal

for the necessary cash, notoriously has a low I. Q., it follows that it is rare to see a professional motion picture which can be enjoyed by an intelligent adult —except, perhaps, in his more frivolous moments.

To produce a motion picture having any art value demands qualities which are beyond the reach of most amateur photographers, as well as beyond both the reach and the ambition of most professional producers; Scanderbeg's sword must have Scanderbeg's arm, and so powerful an instrument as the motion picture demands a Titan to wield it. To begin with, there must be a group of actors and actresses who are competent to portray the emotions which are to be represented. This does not mean that professionals are necessary; almost any intelligent person, and especially a young person, if carefully and thoroughly trained by a competent coach, can give a performance equal or superior to that of a professional actor; the difference is that the amateur can do it only two or three times in succession, whereas the professional can repeat it indefinitely. Of course, one or two performances are enough for a movie, but in the case of an amateur from twelve to twenty rehearsals of each scene will be necessary, and the coach must be a master of dramatic action, of oral inflection, and of dramatic values, and in addition must have infinite patience, a sound knowledge of the technique of coaching, and the magnetic personality of an inspired teacher. In the next place, the producer must have a thorough knowledge of pic-

torial composition, both static and active. This, like good acting, is seldom seen in professional movies, where it is painfully rare to find any single frame which is well composed. The writer has seen one movie in which practically every frame, if isolated from the rest, would have made a satisfactory picture, but that was directed by a man who was a successful painter for many years before he ventured into the motion picture; as a rule, composition is conspicuous by its absence. Then, too, the director must have a knowledge of, and a sensitive feeling for, unity, harmony, suggestion, mystery, contrast, values, and all the other elements which go to make up any work of art. Next, he must have a complete knowledge of plot construction and of the art of writing dialogue, for even though he may not do these things himself, he must know whether or not they are well done. And finally, he must be prepared to spend a great deal of money, and—in the present state of the industry—to look for his reward in the satisfaction of having produced a fine work of art, as it is practically certain that he will never be repaid in cash. Obviously, all this means that the production of motion pictures which can be classed as art is a life work for a wealthy, intelligent, studious, creative-minded enthusiast; if such an individual ever appears on the horizon, we may expect to see some truly great movies, but until then—well, possibly Harry Leon Wilson gave the answer in his

story, Merton of the Movies, when *Mr. Henshaw* remarked:

"Of course the art is in its infancy," and *The Governor* replied:

"Ours is the Peter Pan of the arts. . . . I trust you recall the outstanding biological freakishness of Peter."

Certainly the art of the motion picture, both amateur and professional, is still a long way from growing up.

The amateur motion-picture photographer is often urged to produce plays, some writers even going so far as to suggest scenarios for him to develop. But from what has been said, it is apparent that he is not equipped to produce anything of consequence, and, indeed, it will be found that most of the scenarios offered him are at best nothing more than the broadest kind of slapstick farce. And when such a play—or even a more serious one—is put into production, the producer's ignorance of the many things that he should know, and the actors' ignorance of the art of pantomime, make the result even more painful to watch than would be expected from the amateurishness of the scenario. For these reasons it seems best for the amateur movie worker to restrict his efforts to straight record work, without attempting dramatization, and in that field there is much to be done, and to be done acceptably.

If the amateur will study composition and the other elements necessary to picture-making, will

apply his knowledge to the motion picture—in which the basic art principles are the same as in still photography, though their application is somewhat different—and will consistently remember that every work of art—even so trifling a thing as a limerick—must be built on the secure foundation of an idea, he will be able to produce, without venturing on the difficult, dangerous, and treacherous ground of dramatic art, motion pictures which can be observed with interest and pleasure not only by persons who are familiar with photography, but also by those whose only approach to art is through their appreciation of human values. *Ne sutor ultra crepidam* is a sound maxim in any field of endeavor, and the worker who does his best within his limitations is more likely to achieve success than the one who strives for an expression which is beyond his reach. Travel pictures, sports, news events, nature studies, plant growth, animated table-top pictures—all these and many others are well within the capacity of the intelligent, studious amateur, and can be well worth while. But the more ambitious realm of dramatic art is better left to the yet undiscovered, but greatly desired, self-sacrificing genius of great wealth. Undoubtedly such a man will some day appear; a form of art expression that is potentially so great as the motion picture will not forever be devoted entirely to providing a psychic escape for the less intelligent part of our population. But up to date, no such man has appeared, and meanwhile we can only do as the Count of Monte Cristo advised: "Wait and hope."

CHAPTER XXII

Conclusion

The effort has been made, so far as is possible in a book the size of the present one, to give a discussion of the general principles of the various methods which will be found most useful to the person who wishes to express artistic impulses by means of the camera, but it has not been possible to give a complete description of all the photographic methods which will be of value to such a worker, since to do so would require several volumes the size of this one; and, as was stated in the foreword, no reference has been made to the many technical methods employed in commercial work. It must not, however, be supposed that the photographer can become a pictorialist of the first rank merely through familiarity with technical methods. The aim of the artist must always be to arouse in those looking at his work some emotional mood or sentiment, and to accomplish this other qualities are required besides perfect technique. The finished picture may be likened to the human being, who requires for perfect balance the three qualities of body, mind and spirit, being incomplete unless all three of these characteristics exist in due and suitable proportions. In pictorial

art technique, which is purely objective, may be likened to the body; composition of line and value, being more subjective, may fitly be compared to the mind; and the spirit of the human being finds its counterpart in the expressive impulse underlying the choice of subject and the manner of its treatment. Many workers of the present day, both painters and photographers, are content to produce a pleasing arrangement and perfect technique, feeling that a well-expressed esthetic design is all that is necessary for the production of a finished work of art. Referring to our analogy, however, it will be seen that such a picture may fitly be compared to the hedonist, who, however perfect physically and intellectually, can never leave a lasting impression on his time for lack of a high spiritual motive; and pictures of this nature can have only an ephemeral value, however pleasing they may be esthetically.

The study of composition is beyond the scope of the present book, but many works on the subject exist and there is every facility offered to the student for acquiring skill in this necessary element of art. It may be said that in general more can be learned from a careful study of black-and-white reproductions from the works of great artists than from the study of any book, since the principles of composition are merely verbal enunciations of certain arrangements which past experience has found pleasing, and a sense of composition must be so thor-

oughly ingrained in the worker that its expression will result without conscious effort.

The third quality, that of spirit, cannot be taught, but must result from an inherent desire to do work of an ennobling character. Even this quality, however, may be developed or may be suppressed, and the development or suppression of a lofty desire is to a great extent dependent on surrounding circumstances. It is well known that a high order of mediocrity, in many cases but slightly separated from actual genius, may result from careful and persistent study and effort, but it is not so well known that true genius may be suppressed. There is in the minds of many persons a belief that genius will always show itself, but this is far from being the case, since great genius may be prevented from finding expression through the necessity of producing a relatively low order of work to supply a commercial demand, and may also in many instances be vitiated by unfavorable personal surroundings; but it must not be supposed from this that the writer has any sympathy whatever with the so-called artistic temperament, which he believes to be merely an excuse for the artist to employ mannerisms or self-indulgences which would not be tolerated in the average individual. It will in general be found that artists of the first rank do not possess the "artistic temperament," but in the affairs of daily life conduct themselves quite as well as those individuals whose work is not of an artistic nature. On the other hand, suitable

encouragement favors the development of genius, and where any spark of this exists it may be fostered by proper educational means. Unfortunately, the standard education of this country at the present time is designed to reduce all individuals to a common level, but it is to be hoped that the next few years will see a decided improvement in this respect, signs of such a change not being wanting at present.

The highest development of genius in any branch of human activity can result only from the combination of a peculiar mentality with long and arduous study and effort, but it is by no means impossible for workers who lack the inherent gift of genius to produce artistic results of a pleasing nature and of a very high level, works which will be helpful to many persons to whom the highest productions would be of no value whatever. A certain degree of development is necessary to permit one to appreciate and benefit by any given work, and consequently the finest works of art can appeal only to those who are prepared to understand them, this class of course increasing as the development of the race progresses. Therefore no worker who finds himself lacking in great genius should despair of serving his fellow men, since he will always find an audience and this audience will always be helped spiritually if the artist's original purpose was a lofty one. Everyone who feels any artistic impulse whatever should follow the direction in which it leads, and may be sure

that if he does so he is aiding the progress of the race.

Many workers are so limited by commercial conditions that they can give but a small portion of their time to the study and practice of art, and these are advised to adopt some one method of work and to adhere to it throughout, since a perfect knowledge of all technical methods involves so great an amount of study as to be prohibitive to one whose time cannot be given entirely to this work. Photographers who are thus restricted are advised to employ a non-halation panchromatic film and to familiarize themselves with the use of palladium and gum-palladium, of Fresson, of gum, or of bromoil for printing, since these methods are of wider application than any other.

The writer hopes that this book may prove of value to students of photography, and is confident that anyone who will devote himself with enthusiasm to the use of the camera cannot fail to produce pictures which in addition to affording gratification to the worker himself will also prove pleasing in some degree to all who are interested in graphic art.

Technical (and Other) Data on the Pictorial Illustrations

SOLITAIRE, Frontispiece.

Camera, Eastman #2 View, 8x10; lens, single achromatic; stop, F/8; film, Eastman Superpanchro Press; light, the two candles shown, with no supplementary illumination or reflectors; exposure, 45 seconds; developer, D-76, used for about 3/4 normal time; print on palladium.

SELF-PORTRAIT, page 34.

It is impossible to give precise technical data regarding the work of D. O. Hill. A painter by profession, he became interested in photography as a portrait medium, and worked with it during the years 1843-48, producing about 80 negatives, chiefly portraits of various notable Scotch men and women. The science of photography was at that time in so primitive a state that Hill was obliged to sensitize his own paper for negatives, and to give exposures of 5 or 6 minutes (not seconds) with the sitters posed in direct sunlight. In spite of—and perhaps to some extent because of—these difficulties, Hill made portraits which have never been surpassed, and have rarely been equalled, by any other photographer.

Hill's negatives are preserved in the National Gallery of Scotland, and have been reproduced in half-tone for Heinrich Schwartz's book, Der Meister der Photographie; in photogravure (by J. Craig Annan) for Camera Work; and in gum-platinum by Alvin Langdon Coburn. It is from one of the latter set, presented to the writer by Coburn, that the present illustration is made. The original is 6½x8½ inches.

THE CAVE, page 72.

Here again it is impossible to be exact in the matter of technique. However, having known the late Clarence White for many years, and being familiar with his methods of work, the writer feels that it is safe to say that this picture was made with an 8x10 camera and an Orthonon plate, using either a Taylor, Taylor & Hobson single achromatic lens at F/11, or a Pinkham & Smith Semi-Achromatic at about F/8—probably the former. The plate was undoubtedly developed by inspection, in Rodinal, and the print is an 8x10 platinum.

It is worth noting that much of White's very finest work, which first established his claim to consideration as a true artist, was done while the major part of his time was occupied by business, and he could work at photography only on Sundays and holidays. There may be a hint here for those photographers who excuse the shortcomings of their work by saying that they have so little time to give to photography.

The distinguishing features of White's work are a very fine feeling for composition, and an extreme sensitiveness to the beauty of delicate gradations of light.

ST. MARY'S GRAVEYARD, page 100.

Camera, Soho Reflex, 4x5; lens, Zeiss Tessar; film, Eastman Portrait Pan; no filter; developer, D-76; enlarged negative by reversal on Agfa Commercial film. As to stop and exposure, Dr. Aster informs the writer: "I have no idea what they may have been. The picture was taken in June or July, about 2:00 P. M. I used to run the shutter at a speed which was marked '1/36 second,' and stop the lens down until the illumination on the ground glass looked right. It was probably *about* 1/36, and *about* F/8." The print is an 8x10 palladium, on a buff linen paper.

IN THE PATH OF THE STORM, page 140.

Camera, Premo Supreme, 5x7; lens, Goerz Dagor; Stop,

F/8; film, Eastman Portrait Pan; no filter; exposure, 1/50; developer, pyro; print 8x10, on Opal G, developed in D-72. The picture was taken on July 1, 1919, at about 6:00 or 6:30 P. M., with heavy storm clouds overhead, but a burst of sunlight in the west.

CAPRI, page 180.

Here once more we shall have to rely on the present writer's acquaintance with the artist. It is probably safe to say that this picture was made with a 4x5 Long Focus Auto Graflex, using either a Struss Pictorial lens or a B & L Zeiss Tessar; that an Orthonon plate was used, and developed in Rodinal; and it is absolutely safe to say that the print is an 11x14 enlargement on bromide paper—probably P. M. C.

Although he sometimes made direct enlargements, Struss' chief addiction was to Eastman Etching Black platinum paper, with occasional use of hand-sensitized platinum, and he employed both of these mediums with great delicacy and skill. The distinguishing features of his work are the same as those of White's, though he found more pleasure in the upper register than did White, whose work was largely in a low key.

THE STYGIAN SHORE, page 214.

This is an 11x14 carbon print in Warm Black, on a rough-surface, buff transfer paper.

THE DRIVING WIND, page 246.

Camera, 4x5 Long Focus Auto Graflex; Struss Pictorial lens; F/5.5; Orthonon plate; Cramer Isos III filter (which was about equivalent to the modern K-2); 1/10 second; August, 4:00 P. M.; cloudy, with bursts of sunlight; developer, Kalogen. An 11x14 negative was made on Eastman Portrait film, and a gum-platinum print was made from this, the demonstration in the sky being assisted with a brush and spray of water during development of the gum printing.

PRAGUE: WINTER ON THE RIVER, page 284.

Camera, 3¼x4¼ Reflex; lens, Zeiss Tessar; Stop, F/8; film, Eastman Verichrome; filter, K-1; exposure, 1/25 second; hazy winter light; time, 2:00 P. M.; developer, adurol; print, an 11x14 enlargement on Tumagas, toned blue with gold chloride.

THE BUBBLE, page 304.

Anne Brigman's early work (this picture was made about 25 years ago) was done with a 3¼x4¼ Kodak, using a rapid rectilinear lens and Eastman film. The print is a 6¼x9 enlargement on bromide paper.

At first glance, one receives the impression that Brigman's work is technically very poor, but closer study reveals the fact that she has not merely accepted or ignored the limitations of her medium, but has (perhaps unconsciously) used those very limitations to aid the expression of her thought. Most of her early work was done with nude or draped figures, in the High Sierras, and is distinguished by a wonderful quality of imagination and poetic fancy; she seems to live in a fairyland which is entirely remote from the everyday world, and which is peopled by nymphs, dryads, fauns, satyrs, fairies, elves, pixies, and all the gay, brilliant, tricksy, or sad and romantic folk of the Greek, Roman, and Celtic mythologies. Beyond all question, Anne Brigman is the most brilliantly imaginative worker that photography has yet produced.

In the present case, the model was posed under an overhanging snow bank, which had been eroded by a mountain stream.

THE CONNECTICUT RIVER, page 342.

It was Macnaughtan's habit to work with a 4x5 Graflex and a Cooke anastigmat lens. The negatives, which were on Orthonon or Seed's L. Ortho Non-Halation plates, developed (probably) in Rodinal, were made the basis for combination printing, in the course of

which the definition was softened to a satisfactory degree, the final negative being usually 8x10, and being printed in platinum. His work is notable for great sensitiveness to the subtler appeal of landscape, particularly that of New England; the writer has known a New Englander to sit with tears of homesickness rolling down his cheeks as he looked at one of Macnaughtan's landscapes.

The print from which the present illustration was made is an 8x10 hand-sensitized print on a hand-made Spanish paper, and concerning it Macnaughtan told the writer: "I got the foreground and middle distance in Connecticut, the distance in New Jersey, and the sky in New York." This statement is highly characteristic of the artist's methods, as well as of his personality; the writer does not believe that either Macnaughtan or Brigman is fully conscious of the finely romantic quality of the pictures that they have produced.

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